Understanding the Status of Social License: Adoption of Bt-brinjal in Bangladesh

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Abstract

The discovery of agricultural biotechnology provides opportunities to address challenges in agricultural production and food security, especially for developing countries. However, technology has encountered controversy around the world. Societal views towards genetically modified (GM) technologies differ across different contexts. Today's agriculture operates in a new information environment. Now the public can more readily access information and thus, some consumers or interest groups are concerned about new technologies in agriculture. Interest in the right to know about new technologies brings to the forefront the concept of social license in agriculture and why earning of social license for a new GM crop is important in its acceptance and adoption. Much of the previous work on social license has addressed this issue from a developed country perspective. This thesis examines the concept of social license in a developing country context.

The purpose of this thesis is to examine factors that drive social license for adopting Bt-brinjal in Bangladesh. Bt-brinjal is a new GM food crop in Bangladesh and was approved for commercial cultivation in 2013. The crop is resistant to the fruit and shoot borer (FSB) insect, which causes significant losses in brinjal production in Bangladesh, and is currently undergoing phased-in commercialization. One objective of this study was to develop a conceptual model of social license. Previous studies on public perceptions of and attitudes towards technology adoption are reviewed to understand the concept of social license and a conceptual model of social license is developed based on the literature reviewed. The conceptual model of social license represents the interrelationships among different stakeholders. Developers, government, producers, consumers, NGOs, civil society groups, and media are the main stakeholders with potential influence on the technology adoption process. The literature suggests that social license is difficult to measure directly and thus, the proposed conceptual model of social license uses 'willingness to accept' to examine the level of social license.

To apply the conceptual model of social license in technology adoption in the case of Bt-brinjal, data were gathered through primary survey data collection of different stakeholders across Bangladesh in March and April 2017. Two sets of farmers were surveyed: adopters of Bt-brinjal and non-adopters. The surveys were complemented with interviews with key stakeholders (Bangladesh Agricultural Research Institute (BARI) representatives and NGOs) and a small sample of consumers. Analysis of the farmer survey and stakeholder interview data confirms that most stakeholders have a strong positive inclination about Bt-brinjal with the exception of a few NGOs and civil society groups in Bangladesh. Both adopter and non-adopter farmers expressed a strong willingness to adopt Bt-brinjal. A multinomial logit model (MNL) is estimated to examine the most important reason that influences adopters and non-adopters' willingness to adopt Bt-brinjal. Results show that growing vegetables in the winter season is significant for both adopters and non-adopters and it influences farmers to pick more marketable yield as the main reason for their willingness to adopt Bt-brinjal in the next cropping season. In addition, the total number of pesticide applications to control other pests, yield difference between Bt-brinjal and non-Bt brinjal, adopters' age and off-farm income have significant effects on adopters' decision. Insights from consumer survey and other stakeholders' interviews suggest that stakeholders are not knowledgeable about Bt-brinjal. Although consumers perceived the introduction of Bt-brinjal positively, the small number of NGO representatives interviewed expressed negative perceptions about the introduction of Bt-brinjal in Bangladesh.

This study used Bangladesh as the study area to understand the concept of social license from a developing country's context. Results of this study suggest that at this point in time, Bangladesh has established a strong social license for accepting Bt-brinjal. Although, policymakers in Bangladesh need to take steps to provide appropriate information about this technology to all stakeholders especially farmers (non-adopters) and consumers as they have limited knowledge about the technology.

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The Author

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Chapter 1 Introduction

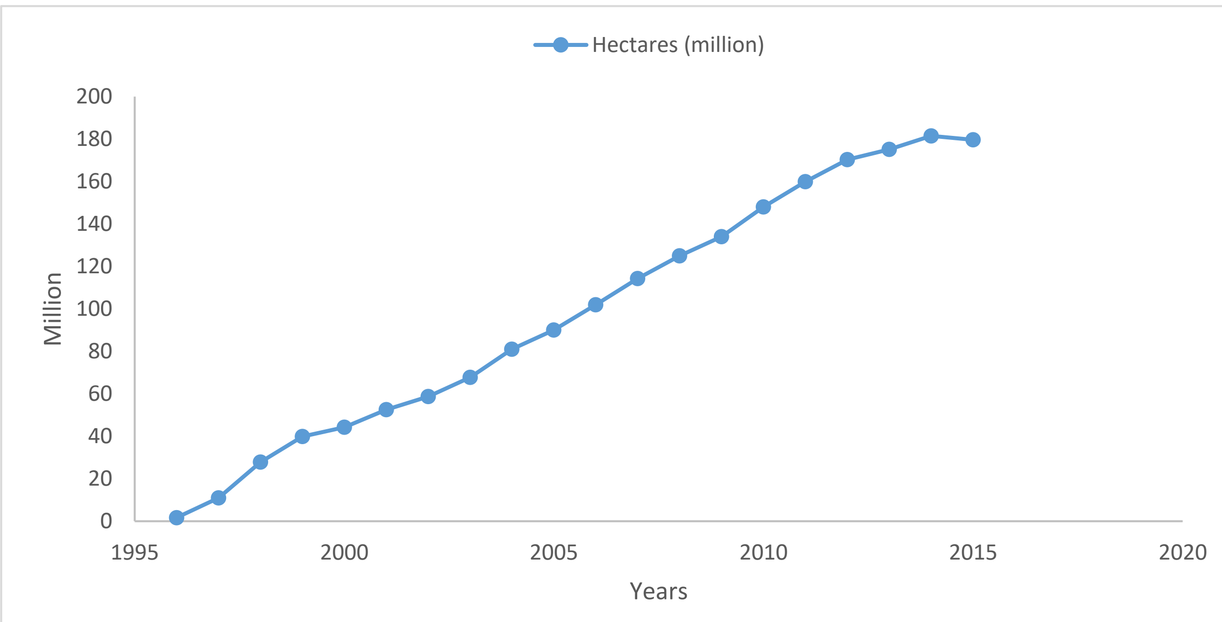
1.1 Background Information

Biotechnology is defined as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (Secretariat of the Convention on Biological Diversity, 1992 as cited in FAO, 2004, p.8). Therefore, biotechnology is a technique where living organisms are used to modify a product, and increasingly, it is becoming an important feature in modern agriculture as well as in the medical sciences (FAO, 2004). Agricultural biotechnology, especially genetic modification (GM) technology, has shown significant potential to increase crop productivity, lower the cost of production and address food security problems in developing countries (Adenle, 2014; Wohlers, 2010). The use of GM technology or transgenic crops started in the mid-1990s and on average, the global cultivation of GM crops has increased by 4% annually (Pino et al., 2016). As a result, more than 18 million farmers in 28 countries around the world now grow GM crops on an estimated total crop area of 181 million hectares (James, 2014; Pino et al., 2016).

Genetically modified crops were initially controversial for a number of reasons, including uncertainty over unknown long-term effects on health, environmental concerns and ethical concerns (Hobbs and Plunkett, 1999). On one side of the debate, proponents of GM technology argue that production of GM crops reduces the use of chemicals in agriculture and can enhance food security through productivity improvements. Evidence to support this argument is found in Adenle, 2014; Bennett et al., 2003; Brookes and Barfoot, 2012; Phipps and Park, 2002; Thirtle et al., 2003; Weisenfield, 2012. On the other side of the debate, opponents worry about the potential environmental and health risks of GM crops and have argued that scientists are unable to predict the long-term effects of consuming GM foods and the impact of biotechnology in the environment from producing GM crops over time. For example, in an analysis of stakeholder attitudes towards genetically modified food in Kenya, Bett et al. (2010) found that most of the gatekeepers (industrial managers and retail buyers) in the Kenyan food industry appreciated the benefits of GM technology but at the same time, they had concerns about human and animal health and the environment.

Despite the ongoing debate surrounding the adoption of these new technologies in agriculture, the global production of GM crops is increasing (James, 2014). Figure 1.1 presents the total global land area of biotech crops from 1996 to 2015. Examining different countries' perspectives, it is found that developed countries are the largest producers of GM crops, such as the United States, Brazil and Canada. For example, the United States grows 40% of all GM crops in the world among all 28 GM producing countries (James, 2014). Brazil and Canada are also large producers of GM crops. Figure 1.2 illustrates the global land area of biotech crops over the period 1996-2015, indicating the hectares grown in developed and developing countries. Although developed countries are the largest producers of GM crops, developing countries are also showing a growing willingness to adopt GM technologies in recent years.

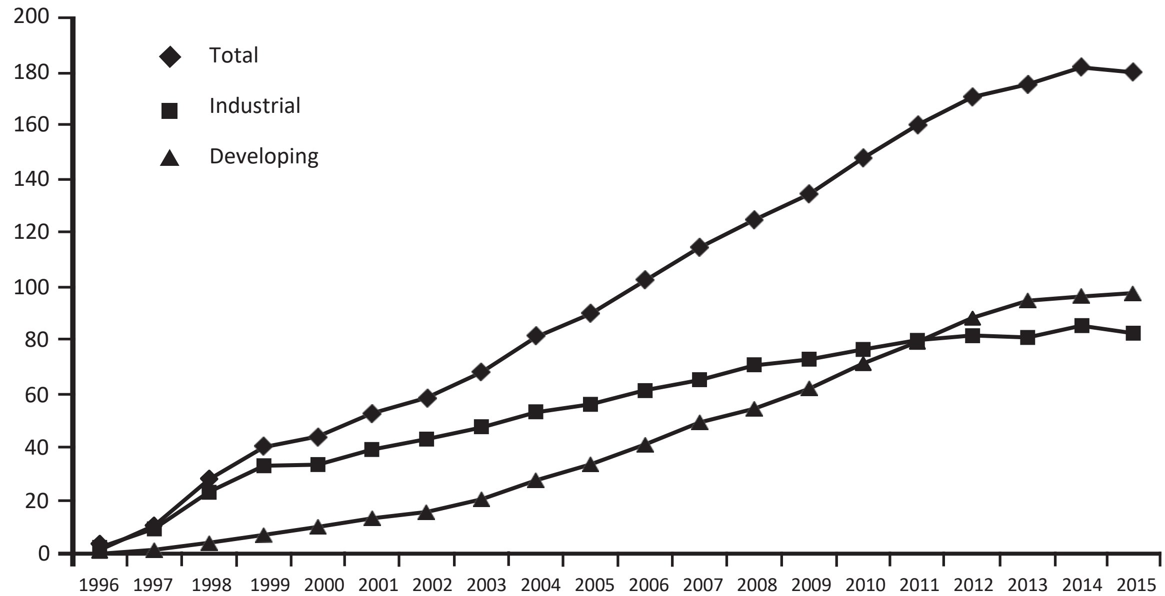
Figure 1.1: Global land area of GM crops, 1996 to 2015 (in million hectares)



Source: Data found from James (2015).

A large number of studies have been conducted examining how public perceptions affect the adoption rate of GM technology, for example Aerni (2005); Adenle (2014); Frewer et al. (2004); Kikulwe et al. (2011); Pino et al. (2016). Public attitudes and perceptions have a crucial role in the acceptability of GM technology (Bett et al., 2010). The concept of public perceptions around the process of adoption of GM technology is not new but recently it has become part of a broader notion of **"Social License"** in agriculture. Generally, social license refers to the ongoing acceptance and approval process of a new technology development by the local community and other stakeholders. A more detailed discussion of social license is presented in chapter 2.

Figure 1.2: Global land area of GM crops from 1996 to 2015: developed and developing countries (in million hectares)



Source: James (2015) p. 13

Perceptions of, and attitudes towards technology adoption may differ from country to country. Research on public perceptions of GM technology in developed countries is well established. This study focuses on developing country perspectives. Aerni (2005) asserted that most people in developing countries are poorly informed about the advanced biotechnology and may be more concerned about immediate risks faced in everyday life than the long-term effects of new technology. Nevertheless, for developing countries, the adoption of GM technology has the potential to address food security problems; yet opposition from public interest groups (Kikulwe et al., 2011) still negatively affects the adoption of GM technology. This study seeks to examine social license for adopting a new GM crop in a developing country context. The developing country analysis focuses on Bangladesh where a GM crop – Bt-brinjal was approved in 2013. Bangladesh is one of the first developing countries to grant regulatory approval to the use of transgenic crops. A brief discussion of the chronological development of Bt-brinjal in Bangladesh is presented in chapter 2.

1.2 Problem Statement

Today's agriculture operates in a new information environment. Modern agricultural technology (especially agricultural biotechnology) has the potential to address challenges in agricultural production, as well as contribute to addressing food security problems in developing countries. However, modern agricultural biotechnology has encountered controversy in many countries. Farming practices are changing day by day. A few generations ago, stakeholders including consumers and other interest groups tended to have a more direct connection to the farm and better understanding of how farmers produced food, while that connection may be now less direct, stakeholders can access and share information easily. Therefore, societal views towards agricultural biotechnology may be affected positively or negatively by the availability of information and opinions about a technology. The concept of social license in agriculture and for a new agricultural technology is therefore very important in gaining social acceptance of the technology. Without social license, a technology is often met with consumer and public resistance and more challenging regulatory environment.

Stakeholder perceptions towards a new technology influence the process of a new technology adoption. Stakeholders' attitudes may differ from one country to another country and even within a country. Thus, the recent approval of the first GM crop in Bangladesh provides an opportunity to examine how social license affects the acceptance and adoption of Bt-brinjal in a developing country context.

Social license is important in the process of GM crop adoption and a great deal of research has examined the concept of acceptance of agricultural technologies and consumers/producers' willingness to adopt these technologies. Curtis et al. (2004) evaluated consumers' attitudes towards GM foods within developing countries. They explain that the majority of previous studies on people's attitudes towards GM foods were conducted in developed countries. They also argue that the perceived level of risks for GM foods may be smaller in a developing country than from a developed country's perspective. While studies on social license or public attitudes toward GM technology have been conducted in different countries, there is a gap in understanding how social license is established and how the notion of social license might differ across different contexts, in particular in a developing country context. Bangladesh is a new GM producing country. Thus, this study examines social license in adopting Bt-brinjal in Bangladesh.

1.3 Research Question and Objectives

This study examines the following research question:

What are the main drivers of social license and who are the key stakeholders involved in establishing social license for the adoption of Bt-brinjal in Bangladesh?

Specific objectives flowing from the research question include:

- ❖ To develop a conceptual model of social license;
- ❖ To apply the conceptual model to a case study of GM technology adoption in a developing country context, to determine what are the main drivers and who are the key stakeholders in establishing social license in Bangladesh; and
- ❖ To derive policy implications for the adoption of GM technologies within developing countries, such as adoption of Bt-brinjal in Bangladesh.

The proposed conceptual model of social license for the adoption of GM crop is developed from a review of literature on social license generally, and literature on the adoption of agricultural biotechnology. To address the second objective (identifying the main drivers of social license for the adoption of Bt-brinjal in Bangladesh), primary survey data was collected in Bangladesh. Farmers, who are currently growing Bt-brinjal (adopters) and others who are not growing Bt-brinjal (non-adopters) participated in the survey. The quantitative farmer surveys are supplemented with a short consumer survey and stakeholder interviews. The empirical analysis focuses on the farmers' survey data, using a multinomial logit model to examine the motivations for a positive willingness to adopt Bt-brinjal.

1.4 Organization of the Thesis

This thesis is divided into five chapters. Chapter 1 has described the background information and problem statement of this thesis. This study is undertaken to examine the factors influencing social license for adopting new technology in a developing country context. Chapter 2 presents the literature review, which includes a brief discussion of Bt-brinjal in Bangladesh and a discussion of social license. This chapter also reviews literature examining stakeholders' perceptions of and attitudes towards technology adoption and concludes by developing a conceptual model of social license. Chapter 3 represents the methodology used in this study, including the design of the survey instrument used to examine stakeholders' (adopters, non-adopters and consumers) perceptions of Bt-brinjal. Descriptive analysis of the survey data is also provided in this chapter. Chapter 4 includes the empirical analysis, including econometric models of reasons for willingness to adopt Bt-brinjal among adopters and non-adopters, as well as a discussion of insights from stakeholders' interviews and a consumer survey. The conclusions to this thesis are presented in chapter 5 that provides a summary of major research findings, policy implications for the adoption of a GM crop in a developing country context, and recommendations for further research.

Chapter 2 Literature Review

2. 1 Introduction

The purpose of this chapter is to review previous studies relating to technology adoption, as well as social license. This chapter reviews the methodology used in previous studies, key findings and relationships to the present study. A review of relevant literature in any research is essential because it helps to identify where knowledge gaps lie. This chapter is divided into five sections. The first section provides a brief overview of Bt-brinjal in Bangladesh (section 2.2). The second section provides the definition of social license (section 2.3). Literature examining stakeholders' attitudes towards technology adoption is discussed in section 2.4, followed by the development of a conceptual model of social license (section 2.5). Conclusions to the chapter are provided in section 2.6.

2.2 Bt-brinjal: A GM Crop in Bangladesh

2.2.1 Overview of the Agricultural Sector in Bangladesh

Bangladesh is an Asian country with only 56,977 square miles of land, which is surrounded by India, Myanmar and the Bay of Bengal. The total population of Bangladesh is 161 million and is increasing rapidly (The World Bank, 2016). The population density was 1,237 per square kilometer in 2015 (The World Bank, 2016). More than 66.48% of the population of Bangladesh lives in the rural areas where agriculture is the main source of livelihood. Bangladesh is an agro-based country with a total cultivable area of 9 million hectares, which is 70% of the total land area of Bangladesh (The World Bank, 2016). Thus, the economy of Bangladesh is mostly dependent on agriculture. The main crop is rice, and other major crops include potatoes, sugarcane, wheat, jute and corn. Bangladesh is a low middle-income country and has faced many challenges since its inception, including poor infrastructure, food insecurity, and political instability. Moreover, the high population density creates other problems including poverty, malnutrition, and food insecurity. Therefore, there is a need for persistent investment in agricultural research and extension, rural infrastructure and irrigation systems to strengthen the agriculture sector as well as the country's economy (Meherunnahar and Poul, 2009). The Government of Bangladesh is trying to introduce new agricultural technologies and therefore, the governmental institutions, public universities and other private institutions have started working on agricultural biotechnology.

To feed the growing population, Bangladesh needs more food and it has been argued that agricultural biotechnology represents an opportunity to meet the food needs of the population as well as to reduce poverty and heighten environmental sustainability (Nasiruddin, 2012). The process of development of agricultural biotechnology started in the late 1970s with plant biotechnology (Choudhury, 1986), with the first 'genetically modified' crops emerging in developed countries in the 1990s. The introduction of genetically modified crops in lower income countries has been slower; however, more recently developing countries are exhibiting higher adoption rates. For example, Bangladesh is now seeing the development of GM crops in the agricultural sector. Researchers suggest that Bangladesh has a considerable potential to adopt GM crops (Choudhary et al., 2014; Nasiruddin, 2012). Indeed Bt-brinjal was approved in Bangladesh in 2013 and Golden Rice is on the way to commercialization.

2.2.2 Crop Biotechnology and Institutional Involvement in the Development of Biotechnology in Bangladesh

Research on agricultural biotechnology was started in Bangladesh in the late 1970s. The Department of Botany at the University of Dhaka, first started research on plant tissue culture[1] and subsequently various research institutions became also involved with tissue culture research, such as the Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Institute (BARI), Bangladesh Jute Research Institute (BJRI), Bangladesh Council of Scientific and Industrial Research (BCSIR), Bangladesh Institute of Nuclear Agriculture (BINA) and Universities like the Chittagong University, Rajshahi University, Khulna University and Jahangirnagar University (Nasiruddin, 2012). After introducing tissue culture, researchers started focusing on genetic engineering research, mostly on gene transformation of jute, pulses and rice for salinity tolerance and fungus resistance (Nasiruddin, 2012). As a developing country, Bangladesh has limited facilities and research capacity for biotechnology, therefore, Bangladesh implemented technologies from other developing countries as part of a research partnership (Nasiruddin, 2012). For example, the BARI obtained the Elite Event-1 (EE-1 expresses insecticidal protein cry1Ac in brinjal) from an Indian Company, Maharashtra Hybrid Seeds Co. Ltd. (Mahyco) under a United States Agency for International Development (USAID) program and the name of the program was The Agricultural Biotechnology Support project-II in 2005 (Choudhary et al.,

[1] The term tissue culture refers to the artificial cultivation of plant tissue

2014). Thereafter BARI, with the collaboration of Mahyco, developed a brinjal variety which is resistant to the shoot and fruit borer (FSB) pests. At the same time, the Bangladesh Rice Research Institute (BRRI), with the collaboration of the International Rice Research Institute (IRRI), developed a GM rice variety (Vitamin A enriched Golden Rice) by introgressing a gene of pro-vitamin A in a local variety of rice.

Different research institutes and their sub-sectional stations are working on biotechnology development activities (Nasiruddin, 2012). Several national and international organizations, with the collaboration of the Bangladesh government, started programs to increase awareness and understanding of biotechnology. Examples of these programs include Agricultural Biotechnology Support Project-II (ABSP-II), South Asia Biosafety Program (SABP) and the Bangladesh Biotechnology Information Center (BdBIC). These programs mostly focus on providing information about biotechnology through several activities. A brief description of these programs is provided below. Various local and international seminars, workshops and training programs are on-going through these programs to improve awareness about agricultural biotechnology in Bangladesh.

2.2.2.1 Agricultural Biotechnology Support Project-II

Agricultural Biotechnology Support Project-II is a United States Agency for International Development (USAID) funded program led by Cornell University. The main aim of this program is to provide benefits from agricultural biotechnology to selected developing countries in East and West Africa as well as India, Bangladesh, Indonesia and the Philippines. The ABSP-II program started in Bangladesh in 2002 and is working to improve awareness about biotechnology through local and foreign seminars, workshops and training programs (Nasiruddin, 2012). Bt-brinjal and Rb potato were first introduced in Bangladesh in 2006 through this program (Nasiruddin, 2012). Rb potato is a GM crop variety, which carries an additional gene - Rb derived from a wild potato species (*S. bulbocastanum*) to control late blight potato disease (Song et al., 2003). The ABSP-II program also assists research and trial activities for GM crops in Bangladesh. The program generates various biotech activities with the collaboration of International Service for the Acquisition of Agri-biotech Applications (ISAAA), SABP and works with governmental organizations, policy planners, non-governmental organizations (NGOs) and the private sector (Nasiruddin, 2012).

2.2.2.2 South Asia Biosafety Program (SABP)

The South Asia Biosafety Program is also a USAID supported program, which is intended to assist India and Bangladesh in further strengthening institutional governance of agricultural biotechnology. The SABP program is a collaboration between the Center for Environmental Risk Assessment (CERA) and the International Food Policy Research Institute (IFPRI) (Nasiruddin, 2012). The program works in Bangladesh to support the Government of Bangladesh to strengthen the agricultural biotechnology sector through public and private institutions, collaborating with the ministries of Agriculture, Health, Science and Environment, district governments, national research and policy institutions, stakeholders in the agricultural sector, NGOs and other development agencies (Nasiruddin, 2012). Some general objectives of the SABP program include:

- Identify and respond to technical training needs for food, feed and environmental safety assessment;
- Develop a sustainable network of trained, authoritative local experts to communicate both the benefits and concerns associated with new agricultural biotechnologies to farmers and other stakeholder groups;
- Facilitate systems for permitting the safe conduct of experimental field trials of new crops developed using biotechnology so that scientists and farmers can evaluate them; and
- Raise the profile of biotechnology and biosafety on the policy agenda within Bangladesh and India and to address the policy issues within the overall context of economic and agricultural development, international trade and environmental sustainability (Nasiruddin, 2012, p. 215).

The SABP program organizes workshops on the safety assessments of GM crop development and to provide information about the potential benefits of agricultural biotechnology among the Department of Agricultural Extension (DAE) officers (Nasiruddin, 2012).

2.2.2.3 Bangladesh Biotechnology Information Center (BdBIC)

The Bangladesh Biotechnology Information Center was first initiated in Bangladesh in 2005 and led by the Department of Biotechnology at Bangladesh Agricultural University, Mymensingh. The BdBIC translated the ISAAA's different publications related to crop biotech into the Bangla language to help those stakeholders who have a language barrier (Nasiruddin, 2012). Through its e-group, it also disseminates information to various biotech players such as biotech researchers, scientists, government and the private sector representatives and media (Nasiruddin, 2012). To raise the awareness and understanding of biotechnology, BdBIC organizes workshops and seminars. It also organizes writing competitions on agricultural biotechnology in collaboration with Bangladesh Agricultural University. The BdBIC has an important role in providing information on the national biosafety policies and guidelines for the country.

2.2.3 Vegetable Production in Bangladesh

Vegetable production is very important to Bangladesh because of the suitable weather conditions. There are two main seasons for vegetable production in Bangladesh - summer/rainy season (Kharif season) and winter season (Rabi Season). The Kharif season runs from mid-April to mid-October and the Rabi season is from mid-October to mid-March. Most of the vegetables are grown in the Rabi season because of the relatively low temperature, suitable humidity and rainfall. The Rabi season vegetables include brinjal, cauliflower, water gourd, cabbage, rabi pumpkin, tomatoes, radish, and spinach, among others. In the Kharif season, the weather remains very hot and farmers are usually faced with irrigation problems. Vegetables grown in the Kharif season include kharif brinjal, potol, lady's finger, karala, arum, and cucumber among others.

Brinjal/eggplant is a vegetable, which is grown throughout the year, so it is also called an all-season vegetable. Vegetable production during the Rabi season is higher than the Kharif season. For example, in 2012-13, brinjal production in the Rabi season was 236,000 tonnes where the kharif brinjal production was only 132,000 tonnes (BBS: Monthly Statistical Bulletin, 2015). Vegetables are perishable and there is no adequate storage system for these perishable goods. As a result, the price of vegetables in the winter season or Rabi season is relatively low compared to the Kharif season. Thus, there is a need for vegetable availability throughout the year to meet consumer demands as well as to provide a more stable marketing environment for producers.

Previous studies have shown that vegetable production has increased with an annual growth rate of 2.8 percent between 1980 and 2003 (Meherunnahar and Poul, 2009) but some studies found that this increased production can be attributed to area expansion which is 2.6 percent and that vegetable yields increased by only 0.2 percent (Meherunnahar and Poul, 2009). According to the Asian Development Bank (2001), the acreage devoted to vegetable production has increased from 1.9 percent to 3.6 percent from 1980 to 2002. However, Meherunnahar and Poul (2009) found that the production of vegetables in 2000-2003 was 1.8 million tonnes and in 1998-1999 was 2.6 million tonnes when brinjal and potatoes were not taken into account. Acreage, production and yields of potatoes and onions are higher among all other vegetables in Bangladesh and brinjal ranks third in terms of production, acreage and yield (see Table 2.1).

Farmers are also faced with a number of problems when producing vegetables. For example, vegetables are more susceptible to various insects than cereal crops and need more care compared to other crops to control insects and pests. Therefore, farmers are using increasing amount of insecticides and pesticides, which increases costs of production.

Table 2.1: Distribution of acreage, production and yields of different vegetables in Bangladesh from 2013-14 to 2015-16

Vegetable	2013-14			2014-15			2015-16		
	Area ('000 acres)	Production ('000 M.ton)	Yield per acre(M.ton)	Area ('000 acres)	Production ('000 M.ton)	Yield per acre(M.ton)	Area ('000 acres)	Production ('000 M.ton)	Yield per acre(M.ton)
Potato	1142	8950	7.84	1164	9254	7.95	1175	9474	8.06
Onion	373	1387	3.72	419	1704	4.07	438	1735	3.96
Brinjal	115	428	3.72	122	450	3.69	125	505	4.04
Pumpkin	63	245	3.89	70	278	3.97	71	291	4.10
Cabbage	40	217	5.30	44	259	5.89	44	295	6.70
Cauliflower	41	183	4.46	48	268	5.58	47	268	5.70
Tomatoes	67	360	5.37	76	414	5.45	67	368	5.49
Garlic	131	312	2.38	141	346	2.45	150	382	2.55
Beans	45	110	2.44	49	122	2.49	50	129	2.58
Radish	64	252	3.94	64	271	4.23	65	281	4.32
Source: Bangladesh Bureau of Statistics, 2017.									

2.2.4 Brinjal Production in Bangladesh

Brinjal is an important vegetable for its commercial and nutritional value in many countries. In Bangladesh, it is known as “Begun” and is a commonly, consumed and popular vegetable. It is a staple vegetable in the diet and rich in nutritional value. White brinjal is said to be good for diabetic patients and an excellent remedy for those who have liver problems (Chowdhury, 2012). Brinjal consists of 92.7 % moisture and also is high in fibre, folic acid, manganese; magnesium and potassium (see Table 2.2).

Brinjal (*Solanum melongena L.*) or eggplant or aubergine is one of the most important vegetables in Asia. China and India are the world’s largest brinjal producing countries. In 2007, China and India contributed 56% and 26% of the world’s production of brinjal respectively (Meherunnahar and Poul, 2009). Brinjal is also an important crop in Bangladesh, ranking third after potatoes and onions in terms of consumption (Choudhary et al., 2014).

Most of the brinjal producers in Bangladesh are small or marginal farmers. The average farm size in Bangladesh is 0.24 hectares (FAO, 2016). Brinjal is produced all over the country and an estimated 150,000 farmers grow it on approximately 50,000 hectares of land (Choudhary et al., 2014). Farmers like to produce different types of brinjal, which vary in colour, shape and size because consumers use different varieties of brinjal for different dishes.

BARI has developed various hybrid varieties of brinjal through its conventional plant-breeding program (Choudhary et al., 2014). Farmers of different areas in Bangladesh are now growing these different varieties of brinjal but the main problem with growing brinjal is that it is easily affected by a number of insect pest species of which the shoot and fruit borer (FSB) insect is the most serious and voracious insect for brinjal production (Meherunnahar and Poul, 2009). The FSB insect first attacks the shoot and also the large leaves of the plant. Later on it attacks the flower buds and fruits of the plant (Meherunnahar and Poul, 2009). Figure 2.1 represents a pictorial presentation of brinjal fruits and shoots affected by the FSB insect. As a result of the FSB insects, the brinjal fruits become less marketable.

Table 2.2: Nutritional value of brinjal (values are per 100 gm of edible portion)

Nutrients	Value	Nutrients	Value
Moisture	92.70%	Calcium	18.0 mg
Energy	24K cal	Magnesium	16.0 mg
Fibre	1.3gm	Phosphorus	47.0 mg
Fat	0.3 gm	Iron	0.9 mg
Protein	104 gm	Sodium	3.0 mg
Carbohydrates	4.00 %	Copper	0.17 mg
Vitamin A	6.4 mg (124 I.U.)	Potassium	2.0 mg
Vitamin B	0.15 mg	Sulphur	44.0 mg
Vitamin C	12.0 mg	Chlorine	52.0 mg
Oxalic acid	18.0 mg	Beta-carotene	0.74 mg

Source: as provided in Table 4 of Choudhary and Gaur (2009) and Meherunnahar and Poul (2009), p.6.

Figure 2.1: Brinjal Fruits and the FSB insect in Brinjal shoot and fruit

Source:
http://scienceblogs.com/tomorrowstable/2010/02/25/httpsidshome1blogspotcom20100/

Source:
http://www.isaaa.org/resources/publications/pocketk/35/

Source:
http://theagrireporter.com/iihr-finds-biological-method-control-pest-attack-brinjal-crop/

All Bangladeshi brinjal farmers are small or marginal and to control this insect, they need to use a large amount of chemical insecticides (Meherunnahar and Poul, 2009). The average lifetime of brinjal crop is 150-180 days and it varies from variety to variety. Farmers started collecting brinjal fruits from the fields after 50-60 days of planting and able to collect fruits on weekly basis. Farmers can collect brinjal fruits at least 3-4 months continuously (on a weekly or biweekly basis) from a healthy brinjal plant. In these 150 to 180 days of a lifetime, a brinjal crop needs to be sprayed with pesticide at least 120-140 times (Meherunnahar and Poul, 2009). Miah et al. (2014) found that about three-fourths of the marketable vegetables, which are grown with the use of pesticide and insecticide, contain pesticide residue which may cause various chronic and acute diseases for consumers.

The cost of pesticide applications becomes an obstacle for the marginal farmers to produce brinjal. The application of different pesticide and insecticide increases not only the cost of production but also hampers the production of brinjal. Moreover, the farmers who are working on brinjal fields and applying pesticide and insecticide are exposed to health risks from the use of these chemicals. For example, Miah et al. (2014) found that pesticide users who have been producing crops for 15-19 years suffer from health problems, such as skin problems, eye irritation, gastro-intestinal diseases, urine and sex related diseases and other short-term health problems.

To reduce the problem and to control the effects of the FSB insect on the brinjal plant, Asian countries are trying to introduce a GM crop named Bt-brinjal which is resistant to the FSB insect. In Bangladesh, GM crops include Bt-brinjal, Golden Rice and Rb potato that are in the trial process and, to date, only Bt-brinjal has been approved in 2013 for commercialization. Thus, Bt-brinjal is the very first GM crop in Bangladesh. Several studies have assessed the potential socioeconomic impact of Bt-brinjal production, for example, Crawford et al. (2003) and Meherunnahar and Poul (2009) find that Bt-brinjal has a significant potential to improve farmers' financial conditions as well as the socioeconomic condition of Bangladesh.

2.2.5 Bt-brinjal in Bangladesh

Bt-brinjal is a GM crop, which carries an additional gene to protect the brinjal fruit from the shoot and fruit borer (FSB) insect. Bt-brinjal carries an additional gene named cry1Ac, which contains insecticidal protein to confer resistance against FSB. Cry1Ac gene is found from an environmentally friendly and ubiquitous soil bacterium, which is Bacillus thuringiensis (Bt) (Choudhary and Gaur, 2009).

Brinjal is an important vegetable in Bangladesh. Thus, to control the FSB insect, Bangladesh started producing Bt-brinjal but the development process of getting approval to produce Bt-brinjal was lengthy. An Indian company, Maharashtra Hybrid Seeds Co. Ltd. (Mahyco), collaborated with the Agricultural Biotechnology Support project-II (ABSP-II) managed by Cornell University, to first introduce this Bt-technology. Bangladesh also obtained this technology from Mahyco in 2005 and the Bt-technology was also donated to public sector institutions in India and the Philippines (Choudhary et al., 2014).

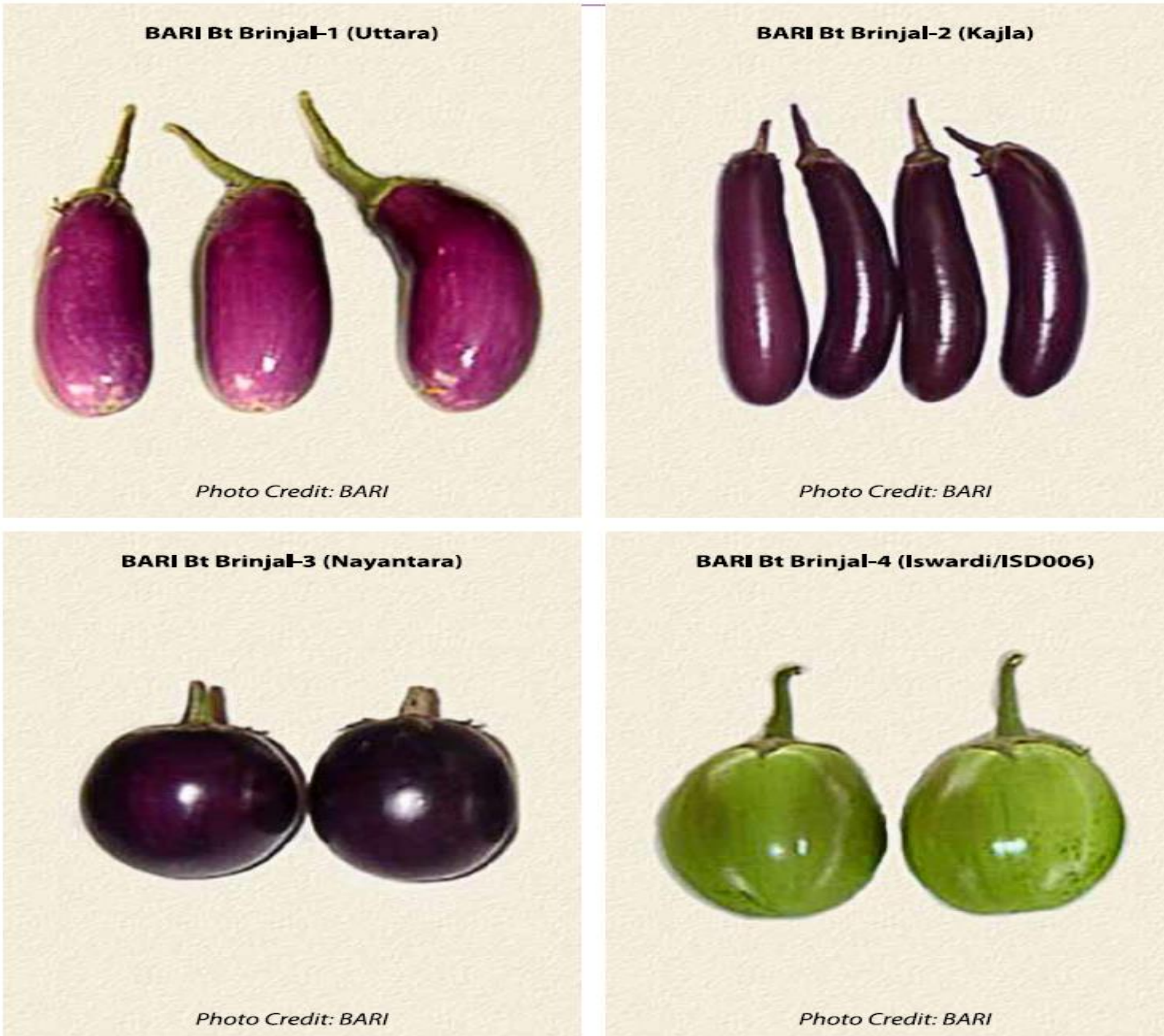
The scientists at BARI, with the collaboration of Mahyco have developed Bt-brinjal by introgressing EE-1 to 9 local brinjal varieties. These local varieties of brinjal are the very popular varieties of brinjal among the small brinjal producing farmers (Choudhary, et al., 2014). Scientists at BARI, with the collaboration of USAID and Mahyco, then started testing Bt-brinjal in Bangladesh in 2005. Bt-brinjal was first tested in a contained and confined environment over the period 2005 to 2008. After different laboratory trial tests, BARI researchers make the decision to provide Bt-brinjal seed to farmers for field trials. The first open field trial was held in different areas in Bangladesh during 2008-2009, using only 6 varieties of Bt-brinjal seed. These 6 varieties were Uttara, Dohazari, Nayantara, Shingnath, ISD006 and Chaga (Choudhary et al., 2014). The second set of field trials were carried out in 2010-11 to 2011-12 by including 3 more Bt-brinjal varieties Kajla, Islampuri and Khatkatia (Choudhary et al., 2014).

During these field trial seasons biosafety studies were also conducted to monitor the environmental effects of producing Bt-brinjal and also to examine the nutritional value of Bt-brinjal. These field trials showed that the FSB insect does not affect Bt-brinjal and the productivity rate of Bt-brinjal is higher than regular brinjal. For example, Kumar et al. (2011) found that a 15 percent adoption rate of Bt-brinjal would increase the production of brinjal by 30 thousand tonnes more than the regular production of brinjal. According to Meherunnahar and Poul (2009) the nutritional value of this new variety was examined, however, Bt-brinjal has the same nutritional value as regular brinjal. The authors also argued that Bt-brinjal is safe for human health and the environment.

After completing the biosafety studies, BARI submitted an application to the National Technical Committee for Crop Biotechnology (NTCCB) of the Ministry of Agriculture seeking approval of Bt-brinjal in Bangladesh (Choudhary et al., 2014). In early 2013, NTCCB constituted an expert committee to evaluate the biosafety of producing Bt-brinjal in Bangladesh. The expert committee then evaluated the biosafety data and they found that Bt-brinjal production is technically sound. The expert committee of NTCCB re-examined all the biosafety data for producing the GM crop. After evaluating all the biosafety data, the NTCCB expert committee sent their recommendation to the National Committee of Biosafety (NCB) of the Ministry of Environment and Forests (MOEF). The National Committee of Biosafety is the most important regulatory agency for the approval of GM crops in Bangladesh. After reviewing and evaluating all of the information, the NCB approved the cultivation of Bt-brinjal in Bangladesh (Choudhary et al., 2014). Among the 9 varieties of Bt-brinjal the NCB approved only four varieties of Bt-brinjal for a limited cultivation on 30 October 2013. The local names of these four Bt-brinjal varieties are Uttara, Kajla, Nayantara and ISD006 (see Figure 2.2).

After receiving the approval, BARI raised 30-35 days old Bt-brinjal seedlings. In January 2014, BARI and USAID along with Bangladesh's Ministry of Agriculture organized a program to provide Bt-brinjal seedlings to a group of farmers (Choudhary et al., 2014). In that program they distributed Bt-brinjal seedlings grown by BARI to 20 selected farmers (see Table 2.3). These 20 farmers were selected from the most important brinjal growing regions of Bangladesh - Gazipur, Pabna, Jamalpur and Rangpur (Choudhary et al., 2014). In the first year of planting Bt-brinjal in Bangladesh around 2 hectares of land was used for growing Bt-brinjal where the total area of brinjal production was 50,000 hectares (Choudhary et al., 2014). Table 2.4 shows the geographic distribution of Bt-brinjal in 2014.

Figure 2.2: Photos of Bt-brinjal varieties



Source: Choudhary et al. (2014), p. ii

Table 2.3: Adoption of Bt-brinjal in Bangladesh in the spring season, 2014

Year	**Adoption of Bt-brinjal (in Hectares)**	**Total brinjal production area (in Hectares)**	**Numbers of Bt-brinjal farmers**	**% of Adoption**
2014	2	50,000	20	<1

Source: Choudhary et al. (2014), p.15.

Table 2.4: Distribution of Bt-brinjal in Bangladesh in the spring season, 2014

Bt-brinjal variety	Location	Area per trial (m2)	No of Bt-brinjal farmers	Distribution of Bt-brinjal seedlings per farmer	Distribution of Bt-brinjal seedlings per location	Total Bt-brinjal area (m2)
BARI Bt-brinjal-1	Rangpur	1000	5	1140	5700	5000
BARI Bt-brinjal-2	Gazipur	1000	5	1140	5700	5000
BARI Bt-brinjal-3	Jamalpur	1000	5	1140	5700	5000
BARI Bt-brinjal-4	Ishurdi/Pabna	1000	5	1140	5700	5000
Total	4	4000	20	4560	22800	20000

Source: Choudhary et al. (2014), p.15.

The development of Bt-brinjal in Bangladesh took several years and the history of this development is summarized in Table 2.5.

Table 2.5: Sequential development of Bt-brinjal in Bangladesh over the period of 2005-2014

Time Period	Bt-brinjal: Approval Process
Contained Trials (2005-06)	**Mahyco** supported by **ABSP-II program**: donated Bt-brinjal technology to BARI (cry1Ac gene event EE-1 was introgessed into nine popular brinjal varieties of Bangladesh)
Confined Trials (2006-07)	**BARI:** BC2 cross carried at BARI
Confined Trials (2007-08)	**BARI:** BC3 cross carried at BARI
Multi-location Trials (2008-09)	**MLTs (7 Bt varieties; 3 locations):** BC3 F2 with three varieties at Joydebpur, two varieties at Jessore and two varieties at Hathazari
Multi-location Trials (2010-11)	**MLTs (9 Bt varieties; 7 locations):** BC3 F3 at Joydebpur, Jessore, Hathazari, Jamalpur, Rahmatpur, Isurdi and Rangpur (season I)

Multi-location Trials (2011-12)	**MLTs (9 Bt varieties; 7 locations):** BC3 F3 at Joydebpur, Jessore, Hathazari, Jamalpur, Rahmatpur, Isurdi and Rangpur (season II)
Multi-location Trials (2012-13)	**MLTs (9 Bt varieties; 7 locations)** MLTs repeated as requested by MoA
July 2013: BARI applied to National Technical Committee for Crop Biotechnology (NTCCB)	
Sept. 2013: NTCCB reported to National Committee on Biosafety (NCB) for final Approval	
30 Oct. 2013: MoEF officially approved four brinjal varieties- Bt-Uttara, Bt-Kajla, Bt-Nayantara and Bt-Iswardi for limited planting in Bangladesh	
22 Jan. 2014: Union Minister of Agriculture Ms. Matia Choudhury distributed Bt-brinjal seedlings to farmers who planted Bt-brinjal in the spring season 2014	

Source: Choudhary et al. (2014), p.17.

A subsequent ISAAA report by James (2014) showed that Bangladesh has approximately 9 million hectares of agricultural land where farmers are using 50,000 hectares of land for producing brinjal and only 12 hectares of land are used for producing Bt-brinjal. Searca (2016) wrote in a blog that Bt-brinjal was planted by 20 farmers on 2 hectares in the spring of 2014 and it reached 10 hectares grown by 100 famers in the next winter season. She also suggested that Bangladeshi farmers showed a strong acceptance of Bt-brinjal. In 2016, more than 500 farmers around the country planted Bt-brinjal (James, 2015). However, while the total number of Bt-brinjal farmers is increasing every year; it is still at the stage of technology transfer project rather than full commercial adoption. Lynas (2014) wrote in his blog that Bangladeshi farmers are very happy to produce Bt-brinjal as the Bt-brinjal fields are free from the FSB insects. As a result, the farmers' cost of production decreases and their incomes increase. He noted a willingness among farmers to produce more in future cropping seasons.

During the phased-in commercialization of Bt-brinjal (2013-2017), at present, Bt-brinjal seeds are not transacted in a pure market setting. The Bangladesh Agricultural Research Institute produces Bt-seeds in their research fields and makes them available to farmers. However, while Bt-seeds are not fully commercialized, the products from Bt-brinjal (the fruit) are commercially available for sale in the regular market channels. Farmers, who produce Bt-brinjal, are able to sell them in the market, along with conventional brinjal. Currently, there are no regulations or policies requiring labelling of Bt-brinjal in Bangladesh. According to the most recent report on Agricultural Biotechnology in Bangladesh (2017) published by the USAD Global Agricultural Information Network (GAIN) (2017), Bangladeshi farmers do not use any specific labelling to sell their vegetables and consumers like to buy vegetables from the local wet market[2]. The report also confirmed that Bt-brinjal is sold in the market without any specific labelling. Thus, while Bt-brinjal farmers in Bangladesh many choose to voluntarily label Bt-brinjal fruits in the market, they are not required to do so.

A number of studies have been done during this commercialization phase to examine the cost and benefits of Bt-brinjal and non-Bt Brinjal. Choudhary et al. (2014) assessed the benefits of Bt-brinjal from the first year production in 2014. They reported that 2014 was the successful year of commercialization and Bt-brinjal effectively controlled the FSB insects. Farmers did not spray any insecticides at all to control the FSB insects, whereas non-Bt brinjal fields were sprayed at least twice a week against the FSB insects. Kumar et al. (2011) conducted a study in India to examine the potential benefits of Bt-brinjal and they found that Bt-brinjal would increase the yield by 37% compared non-Bt brinjal and led to a reduction of 42% in the total insecticide use over non-Bt brinjal. They also reported data from the All India Vegetable Improvement Project (AICVIP) regarding the number of pesticide applications in Bt-brinjal fields (data were collected from the trial fields of Bt-brinjal in India). This project suggested that the number of pesticide applications against the FSB insects were reduced by 77%. Rahman et al. (2016) conducted a study in the Jamalpur district in Bangladesh to examine the profitability of Brinjal production. They found that human labor and chemical use in brinjal fields are the most important factors in the brinjal production. They estimated the net return from the brinjal production is approximately BDT 303,358 (CAD ~$4674) per hectare[3].

GM technologies are controversial in nature but unlike in other countries, attitudes toward GM crops appear to be relatively positive among different stakeholders in Bangladesh. Nasiruddin (2012) suggests that the Bangladesh government, scientists, researchers, as well as producers, have favourable attitudes towards biotechnology. However, while public opinion may be supportive of GM technologies, some NGOs, media and environmentalists exhibit negative attitudes toward GM

[2] USAD= United States Department of Agriculture
[3] The latest conversion rate between Canadian dollar (CAD) to Bangladeshi Taka (BDT) is 64.90 (on March 8, 2018)

crops. An example is UBINIG (Unnayan Bikalper Nitinirdharoni Gobeshona), a community-led NGO in Bangladesh which translates into English as Policy Research for Development Alternative. UBINIG works as a research and consultancy organization for the socioeconomic development of rural poor and marginal people in Bangladesh. It does research on different social development issues. UBINIG organizes several events against Bt-brinjal. Bt-Begun Birodhi Morcha (Coalition against Bt-brinajl) is one of them and it works as an alliance of various social groups (environmentalists, journalists, lawyers, women and health workers). As part of this event, it claims that Bt-brinjal is a threat to human health, biodiversity and the environment. NAYAKRISHI andolon is another program supported by UBINIG. The main goal of this program is to inspire farmers to use conventional seeds without using any agricultural chemicals. As part of this movement, NAYAKRISHI also organizes different events to share their perspectives on the new GM crop in Bangladesh.

To date, there is a lack of information about the extent to which social license for the adoption of Bt-brinjal has been established. This study seeks to examine the factors affecting the development of social license for Bt-brinjal adoption in Bangladesh and who are the main stakeholders influencing social license.

2.3 Social License

Social license is relatively new in agriculture, but the concept is not new at all. The concept of social license may differ from one sector to another and even country to country. Therefore, it is difficult to define social license. In the context of Canadian agriculture, the Canadian Federation of Agriculture (CFA, 2015) defined social license as “the ongoing level of acceptance, approval and trust of consumers regarding how food is produced”. The Canadian Centre for Food Integrity (CCFI, 2016, p.5) defines social license as “the privilege of operating with minimal formalized restriction, (legislation, litigation, regulation or market mandates) based on maintaining public trust by doing what’s right” and they also define public trust as “A belief that activities are consistent with social expectations and the values of the community and other stakeholders”. Crop Life Canada (2017) also defines social license as “Social license refers to the level of public trust granted to a corporate entity or industry sector by the community at large and its key consumer base.” In addition their definition of public trust is “the belief that activities are consistent with social expectations and the values of stakeholders, and earned through industry engagement, operating practices, and expressed values. Social license is slow to build, but quick to erode. Industry tacitly garners public trust by doing what is right."

Social license is a very common concept in the mining sector (resource sector). According to Nelsen (2006), social license creates relative transparency between the industry and its stakeholders by sharing information, values and practices about the industry. Therefore, the negotiation among different stakeholders and the industry itself helps to acquire accountability and credibility for the industry. Boutilier and Thomson (2011) defined social license as a community's perceptions of the acceptability of a company and its local operation, which means that the local community has the power to grant the social license for developing a project.

Social license is usually informal and intangible because it is imbedded in beliefs, perceptions and opinions held by the local population and other stakeholders. Social license is also dynamic in nature because it depends on beliefs, opinions and perceptions and they are subject to change over time as additional information is developed. The perceptions toward a new technology may vary from person to person and their attitudes may change over time. Social license is consistent with social norms and beliefs and differs from regulatory license. Regulatory license involves complying with specific legislation and regulatory requirements and procedural conditions (Yates and Horvath, 2013). A regulatory license is normally defined as a formal license and it provides permission to use. A regulated governmental authority also authorizes regulatory license; in contrast, social license is informal and is not regulated by a specific governmental authority.

Social license has several components, all of which are important in the process of establishing or developing a technology in agriculture. Trust is the main element of social license and to make a technology trustworthy, it is also necessary to obtain legitimacy and credibility. Studies from the mining sector such as Moffat and Zhang (2014) and Boutilier and Thomson, (2011) explain elements of social license and how they are measured. Boutilier and Thomson (2011) developed a conceptual model of social license where they defined four levels of social license and three essential elements of social license. The levels of social license are withheld/withdrawn, acceptance, approval and psychological identification, while the elements social license are trust, credibility and legitimacy.

Social Legitimacy: The word 'legitimacy' comes from a Latin word 'legitimus' means "lawful" or "fixed by law, in line with the law" (Melé and Armengou, 2016). Legitimacy is related to the acceptance or justification of a technology adoption or an industry's existence. Social legitimacy is based on established norms, which may be legal, social or cultural. Social legitimacy may be formal or informal in nature to obtain social license. In any sector, either agriculture or mining, it is necessary to know and understand the social norm of the local community before introducing a new technology. Melé and Armengou (2016) conducted a study on the mining sector to examine how legitimacy is related with social license to operate. They found that legitimacy helps a company to convince the local people and other stakeholders of the ethical acceptability of their projects. Durant and Legge (2006) argue that the public's perceptions and attitudes toward GM foods are influenced by general political ideology, gender, socioeconomic status and social beliefs about politics, society and religion. Social legitimacy is the first step to move into the acceptance level of a technology adoption. Without social legitimacy, social license cannot be established in a society (see Figure 2.3). A technology remains in the rejection areas (withdrawn level) if social legitimacy does not exist for this technology.

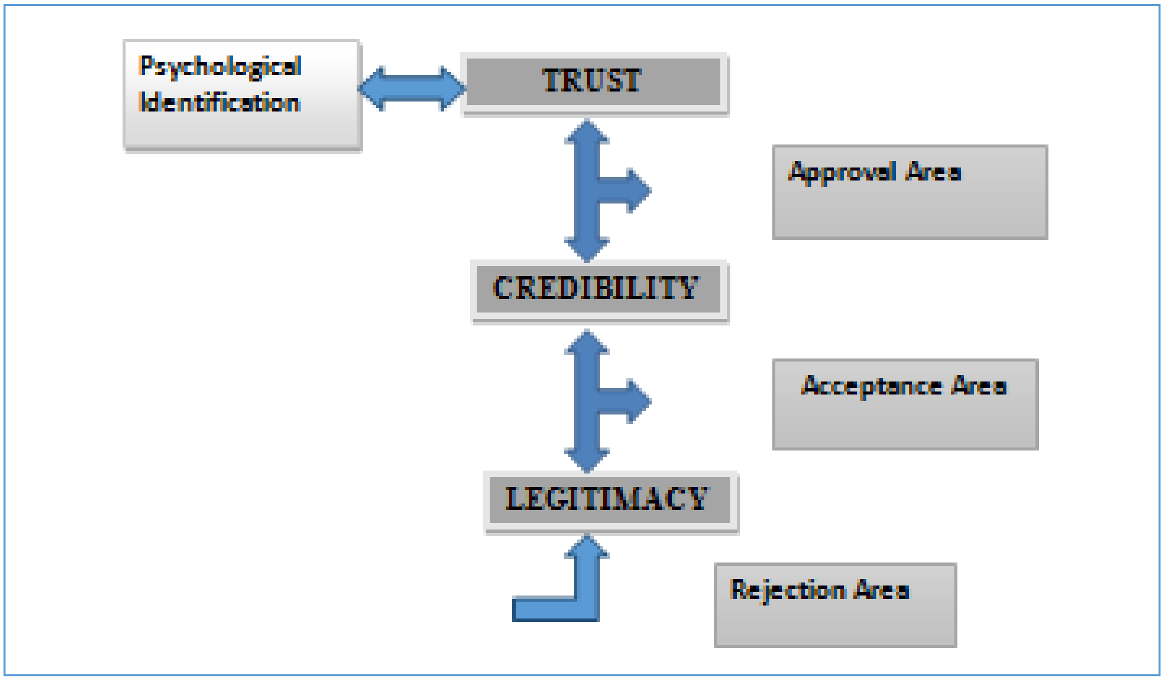
Credibility: Credibility is the second step of gaining social license. Credibility means the quality of being trustworthy. In the context of the mining sector, the institutions or organizations who are trying to introduce a new mine, need to gain credibility from the local community. This concept is also applicable in the agriculture sector. Boutilier and Thomson (2011) state that negotiation between the industry and its other stakeholders facilitates knowledge exchange and allows the parties to learn about each other. The more clear and precise information that is provided, the more credibility the technology developer will gain. Credibility is also related to the commitments that a technology developer company makes to the community. If a company fails to fulfill their commitments to the community, the level of credibility will reduce. As the second element of social license, credibility allows the technology adoption to progress into the approval level of social license.

Trust: Trust is the key element for gaining social license. The more trust there is in government institutions and other regulatory organizations, the stronger is social license for technological development. Trust in government, positive views on science and technology and also positive media influences may reduce the level of risk perception for GM foods (Curtis et al., 2004). Kikulwe et al. (2011) conducted a consumer survey in Uganda to examine consumers' attitudes and institutional awareness and trust towards GM regulations. They find that trust in institutions varies significantly among different consumers. For example, in Uganda, governmental organizations are the most known and trustworthy whereas the research and education sector is considered as the least known and trusted among consumers. Thus, trust is a very important element for establishing social license. The existence of social legitimacy, credibility and trust can build strong social license for a adoption of a technology.

Figure 2.3 depicts the elements and the various levels of social license and is adapted from Boutilier and Thomson (2011), where they divided the whole adoption process into four levels and three elements. Elements are the drivers to reach from one level to another. In the process of technology adoption, the first level is 'withdrawn', where social license does not exist in the society. The presence of legitimacy leads to the level defined as 'acceptance'. In the acceptance level, technology developers try to acquire credibility by communicating and sharing their knowledge with other local stakeholders. As a result, legitimacy and credibility help to build trust. Thus, the presence of legitimacy, credibility and trust lead to the 'approval' level where local community 'grants' the social license.

The conceptual model of social license in the mining sector (Figure 2.3) may help to identify the factors that influence social license in the agriculture sector. For example, Boutilier and Thomson (2011) stated that trust, credibility and legitimacy are important factors for gaining social license in the mining sector. Ideas from Boutilier and Thomson's (2011) conceptual model inform the development of a new conceptual model in this thesis where it is expected that trust and credibility will also be important factors influencing social license in the agriculture sector. The new conceptual model of social license aims to identify the factors that influence social license and who are the most important stakeholders in the process of technology adoption in the agriculture sector. Before presenting the new conceptual model of social license in the context of the development and adoption of Bt-brinjal in Bangladesh, a review of literature examining the factors affecting biotechnology adoption and acceptance is first presented.

Figure 2.3: Elements of social license and its different levels



Source: Boutilier and Thomson (2011), p. 2

2.4 Stakeholders Attitudes towards Technology Adoption

Agricultural biotechnology has led to the introduction of many new technologies and shows significant potential in agriculture, yet because of the controversial transformative nature of agri-biotechnology, risk analysis has become a major focus among researchers. Many studies have assessed the risks and benefits of agricultural biotechnology such as Aerni, 2005; Amin et al., 2011; Finucane and Holup, 2005; Frewer et al., 2003; Pino et al., 2016; Wieczorek, 2003. The risks and benefits of biotechnology affect producers, consumers and other interest groups. A large number of studies have assessed consumers' attitudes and perceptions towards GM foods such as Curtis et al., 2004; Kikulwe et al., 2011 and Pino et al., 2016. Studies on broader societal views of GM foods have also been conducted by Frewer et al., 2004; Pino et al., 2016, Aerni, 2005; Adenle et al., 2013, Aerni and Bernauer, 2006, and Kikulwe et al., 2011.

Social license for GM technology mostly depends on consumers and producers decisions who are very important stakeholders for approving a GM technology. A higher willingness to purchase among consumers will lead to a stronger social license for a GM technology. Consumers' attitude toward GM food may differ depending on perceptions of risks and benefits of GM food. Kikulwe et al. (2011) found that consumer characteristics and perceptions affect the willingness to buy GM products. They identified three types of factors in terms of consumers' attitudes towards GM technology, including: benefit factors, health factors, food and environmental factors. Benefit factors encompass the potential benefits of GM food to consumers, while health and environmental factors encompass perceptions of unknown long-term risks. In a developing country context, consumers, including so-called sole consumers and adopter consumers, may exhibit different perceptions of GM products. Adopters are those who produce GM crops for consumption as well as for selling, while sole consumers are those who only consume and do not produce the product. Kikulwe et al. (2011) find that sole consumers consider product quality more important, while the adopter consumers are more inclined to consider the environmental factors.

Pino et al. (2016) conducted a study to examine how a producer's corporate social responsibility (CSR) affects consumers' willingness to purchase GM foods. Producer's corporate social responsibility refers to those practices, which demonstrate the social wellbeing. According to Carroll (1979), CSR encompasses four kinds of responsibilities, including - economic, legal, ethical and philanthropic responsibilities. Economic responsibility means producers can expect profit from their business by producing and selling their product. Legal responsibilities means the companies are expected to follow the requirements executed by legal authorities and ethical responsibilities are those practices, whereby companies are expected to provide the right information about their business to society (Pino et al., 2016). A philanthropic responsibility includes those actions which help producers to share information about their product to local people. Thus, a producer's CSR means that producers contribute to solve social problems beyond their own business profit. Pino et al. (2016) found that a producer's philanthropic responsibility has significant effects on consumers' perceptions towards GM food.

Producers' perceptions towards a GM product is also a key factor affecting social license and producers' willingness to adopt depends on their perceptions of risks and benefits. It is found that adoption of GM crops is relatively high among commercial and small-scale farmers because of lower costs of production and higher yielding varieties. Adenle et al. (2013) stated that in South Africa farmers are willing to pay more to buy GM seed because it provides more yield compared with conventional varieties. Krishna and Qaim (2007) conducted a study in India using ex ante analysis of the adoption of Bt-eggplant. They used the contingent valuation method to examine farmers' willingness to pay. The most interesting finding of this study was that the average willingness to pay for Bt-brinjal is more than four times the price of conventional brinjal. Kolady and Lesser (2006) conducted a study in India to examine producers' willingness to adopt Bt-brinjal when hybrid brinjal is available in the market. They used a probit model to analyze how hybrid brinjal growers act differently when Bt-brinjal is introduced in the country.

Stakeholder attitudes toward GM technologies may differ from country to country. Some stakeholders may have faith in GM technology due to its significant potential problem-solving features, whereas some may not. Although, stakeholder attitudes may differ from one to another, there is an interrelationship among all the stakeholders. Biosafety regulation is the first requirement to start any biotechnology research and development (R&D) in any country and government is responsible to establish a set of biosafety regulations. Researchers, academia and private industries (technology developers) who are responsible for the technological development, play significant roles in the technology adoption process. Therefore, public trust in biosafety regulation is one of the main dimensions that affects stakeholders' perceptions towards GM technologies. For example, Adenle et al. (2013), stated that South Africa is now producing GM crops successfully with a strong biosafety regulatory framework; whereas Egypt and Tunisia lack adequate biosafety regulatory frameworks to conduct GM crop field trials.

Stakeholders also worry about the potential risks and benefits of GM foods. Thus, risks and benefits factors also affect the social license for a technology adoption. Adenle et al. (2013) stated that the benefit factors have a significant role in the adoption of GM crops. It is found that commercial and small-scale farmers are more likely to adopt GM crops due to the benefits of higher yields, insect resistance and herbicide tolerance. Wohlers (2010) conducted a study to examine how national differences in political culture provide a new dimension in the formation of policies regarding GM foods in the United States, Canada and EU. He used the Uncertainty Avoidance Index (developed by Hofstede) to trace differences among national regulatory policies around GM food. An Uncertainty Avoidance Index shows how risk avoidance attitudes vary across different countries and regions. This index indicates the ranks and scores by country and regions. Wohlers (2010) found that the United States and Canada are willing to take risks associated with GM foods in terms of potential high benefits from GM crops, whereas European countries show a low uncertainty tolerance attitude.

Zilberman et al. (2013) explained the causes of difference between GM policies in the US and EU. They claimed not only consumers' perceptions, but other stakeholders' perceptions are important in the development process for GM crops. They also identified four reasons for the difference between GM policies in the US and Europe. First, the leading companies of GM technology have more influential power in the United States' political system than the European political system. Second, GM technology has less direct consumer benefits in Europe because in the US the major GM crops are corn, soybean and cotton. Global demand for these crops is rising. Thus, the US farmers showed a significant willingness to produce GM crops. Third, some environmentalist groups in Europe such as Green parties and Green politicians, have a greater influence over policy making which helps to block the approval of GM technologies. Fourth, the trust in government over establishing food safety rules and regulations is higher in the US than in Europe because some European consumers have relatively more trust in NGOs. All these reasons make a difference between GM policies in the US and Europe. Thus, it is also necessary to see how GM policies or adoption of GM crops differs between a developed country and developing country context.

A few studies also have assessed the position of other stakeholders towards genetically modified crops. Aerni (2005) and González et al. (2009) found academia, government, producers and private industries are often the proponents of genetically modified crops, where the non-governmental organizations (NGOs) and churches are often the opponents.

This literature review reveals that social license for a new technology depends on different stakeholders' attitudes and preferences. Consumers, producers, governmental agencies, NGOs and technology developers including– researchers, academics and private industries are the main stakeholders in the development of new technology. Stakeholder groups may differ in their perceptions towards GM technology. Factors that drive social license were also identified from the literature. A summary of the literature review is presented in Table 2.6 and helps to inform a conceptual model of social license. A proposed conceptual model of social license is depicted in Figure 2.4 based on the reviewed literature on social license and on technology adoption in agriculture.

Table 2.6: A summary of literature reviewed

Authors	Study	Country	Methodology	Results
Pino et al. (2016)	Consumers' perception, producers' corporate social responsibilities, GM foods	Italy	A confirmatory factor analysis	Factors: Producers Philanthropic and legal responsibilities
Adenle (2014)	Stakeholders perceptions: policy makers and scientists, GM technology	West Africa: Ghana and Nigeria	Based on qualitative analysis	Factors: Potential risks and benefits, status and development of biosafety regulatory framework, role of science and technology innovation in agriculture
Adenle et al. (2013)	Views and positions of stakeholders, development and adoption of GM crops	Africa	Based on qualitative analysis	Factors: Role of biosafety rules and regulations, risk and benefit factors
Zilberman et al. (2013)	GM policies in the US and Europe	The United States and Europe	Based on literature review	Identified four reasons for differences in GM

				policies in the US and Europe
Kikulwe et al. (2011)	Consumers' perceptions, institutional awareness and trust, GM products	Uganda	Based on qualitative analysis, cluster analysis	Factors: benefit factors, health factors and environmental factors
Wohlers (2010)	Risk perceptions, different national political culture, GM technology	The United States, Canada and EU	Based on Uncertainty Avoidance Index	The US and Canada have modified regulatory framework for GM technology, while EU has very strict regulatory policies for GM food.
González et al. (2009)	Stakeholders' position, GM crops	Brazil	Cluster analysis Logit model	Proponents: Local and multinational industry and part of the government. Opponents: NGOs
Krishna and Qaim (2007)	Ex ante analysis, Bt-eggplant, willingness to pay	India	Contingent valuation method, Multinomial logit model	Large-scale farmers prefer Bt-hybrid seeds and resource-poor farmers prefer Bt-OPV

Alexander and Mellor (2006)	Determinants of the adoption of CRW corn	Indiana, the United States	Probit model	Factors: Market access variables, price variables and insect resistant plan management requirement
Aerni (2005)	Stakeholder interest, public debate of risks and benefits of GM, developing and developed country perspectives	South Africa	Cluster analysis	Proponents: academia, government, producers, consumers organizations and industry Opponents: NGOs and Churches
Frewer et al. (2004)	Societal aspects, public controversy, GM foods	Europe	Based on literature review	Risk perceptions and attitudes, public trust in regulatory institutions

Literature shows that societal views towards genetically modified technology may differ across different contexts, particularly between developed and developing countries. For example, Table 2.6 shows that the United States and Canada have the modified regulatory framework for GM technology adoption, while other countries (developing countries) are more concerned about the risks and benefits of GM technology. Consumers' perspectives have more influence in establishing social license for adopting a technology in a developed country context than a developing country context. Producers' attitudes may also differ in different contexts. Also, in a developed country there tends to be a sharper distinction between producers and consumers, while in a developing country context the two groups are much closer, or an adopter may be both a producer and a consumer.

2.5 A Conceptual Model of Social License

A conceptual model is a representation of a system that encompasses all the concepts together and helps people to understand the system. This study proposes a conceptual model of social license based on the literature reviewed. The hypothetical conceptual model of social license is presented in Figure 2.4. The figure proposes that different groups of stakeholders are interrelated to each other and have a direct or indirect influence on the technology adoption process (social license). However, it is known that, while developer groups may be the most important stakeholders for developing a new technology, other stakeholders including consumers, producers, government and NGOs also have an important influence on social license for a new technology. In Figure 2.4, straight lines and dotted lines indicate the direct and indirect relationship between two groups respectively. Factors that are hypothesized to influence social license directly or indirectly for different stakeholders are shown beneath the relevant stakeholder.

Social license means a local community's level of acceptance of a new technology. Local community mostly refers to the consumers and producers who have the major influence to grant social license, since if producers do not adopt the technology and/or consumers do not purchase products produced with the technology, there can be no social license. There is no specific measurement for social license. Therefore, willingness to accept is used to measure the level of social license. It is assumed that: a) the higher willingness to accept a technology by local stakeholders, the higher the probability of social license being granted for that technology and b) the lower the willingness to accept a technology by local stakeholders, the lower the probability of granting social license.

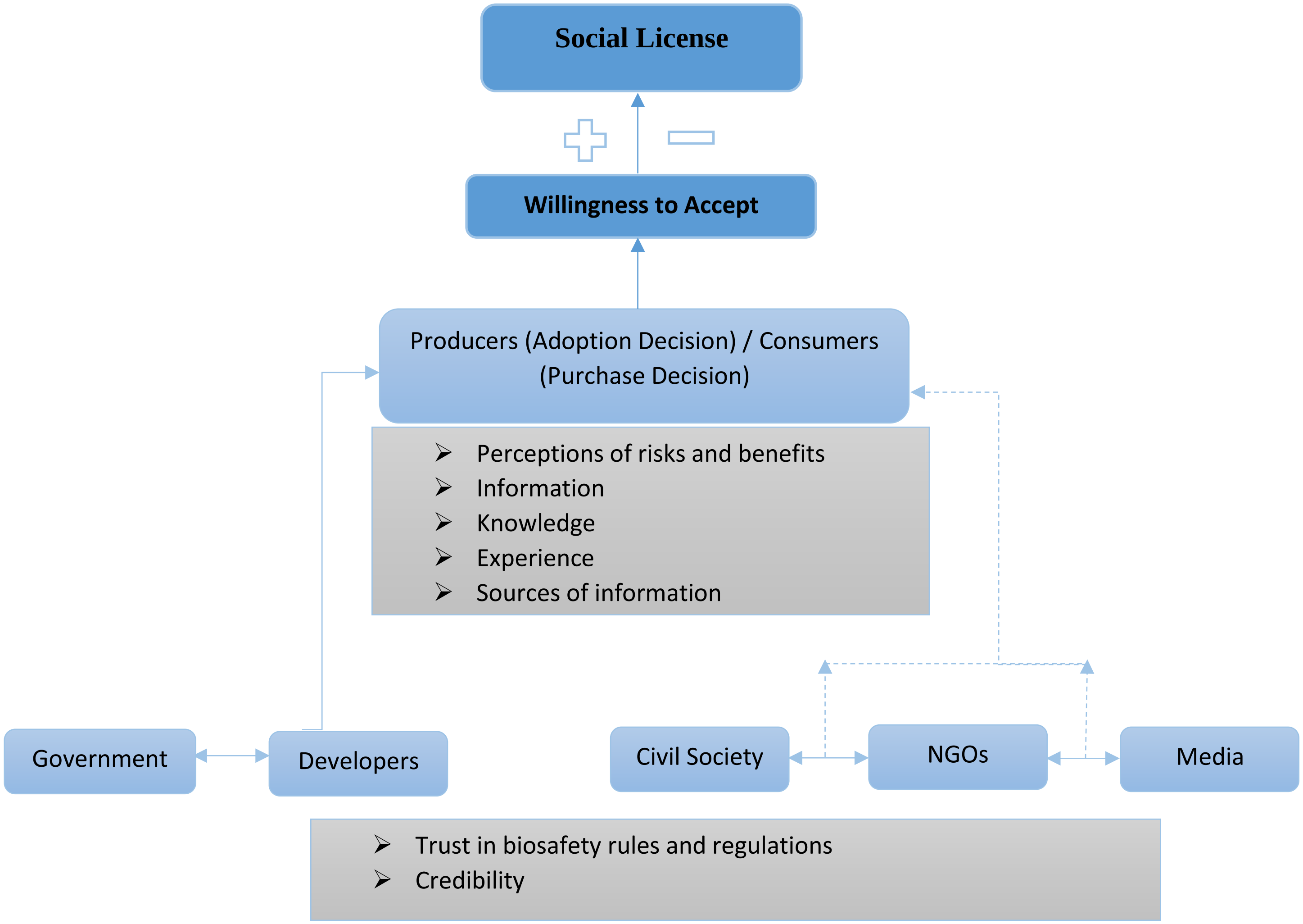


Figure 2.4: A proposed conceptual model of social license

Government is responsible to build biosafety rules and regulations before introducing any GM products, while technology developers are responsible for developing those technologies. Communication with other stakeholders by sharing information about biotechnology and its rules and regulation may help to acquire credibility and trust. The literature review also reveals that trust and credibility are very important factors that influence social license. Thus, it is assumed that there is a direct relationship between technology developers and government. Developers also have a direct connection to producers and consumers (see Figure 2.4). The producers and consumers are important stakeholders to establish social license for a technology. However, a strong regulatory framework developed by government may also influence the establishment of social license. Although not depicted in Figure 2.4, it is also recognized that the regulatory framework that evolves may itself be influenced by the social license processes.

NGOs, civil society groups and media also may influence social license. These groups are interrelated to each other and have a direct or indirect connection to each other. In this conceptual model, it is assumed that these groups may have an indirect connection with consumers and producers as well. However, these groups typically provide information to consumers as well as producers. Trust in biosafety rules and regulation and credibility are two main factors that may influence their perceptions towards a new technology. Consumers and producers preferences may change over time depending on information availability. Newspapers, TV shows, online newspapers and the Internet are popular sources of information. Therefore, people are now getting new information very quickly. As a result when new information is developed, people's attitudes and perceptions towards GM technology may change and these groups may influence them.

Figure 2.4 shows that consumers and producers have a direct relationship with social license, as they are the final users of that technology. The willingness to accept GM products may also increase the adoption rate of this technology. Thus, the direct line from consumers/producers groups to a willingness to accept measures the extent of social license (see Figure 2.4). Consumers and producers' willingness to accept a GM product depends on their own perceptions of risks and benefits. Consumers and producers are depicted within one box in Figure 2.4, reflecting the close relationship between these groups that is often found in a developing country context, particularly for the consumers who are located in rural areas. However, it is noted their attitudes toward GM products may differ from each other, particularly in different contexts. Consumers from developed countries may perceive the GM technology differently than those in developing countries. Developed countries consumers can access information about the GM technology relatively easily, while this may be the case for urban consumers in developing countries. Thus, accessibility of information may influence consumers' attitudes towards GM technology. Therefore, knowledge of biotechnology, information availability, experience and important sources of information may influence their willingness to accept GM products.

The proposed conceptual model of social license in the agriculture sector (Figure 2.4) reveals that consumers and producers are the most important direct stakeholders who initially grant social license for a new GM commodity. The government, technology developers, NGOs, civil society groups and media are also significant stakeholders in the process of GM approval. Thus, these stakeholders are interrelated to each other. Trust in biosafety regulation, credibility, perceptions of risks and benefits, knowledge of biotechnology are key factors influencing social license for a new technology.

2.6 Conclusions

The first section of this chapter provides a brief overview of Bt-brinjal in Bangladesh. Brinjal is the third most important crop in Bangladesh and the FSB insect is the most perilous insect for brinjal plants. Therefore, farmers in Bangladesh need to use large amounts of chemicals (pesticides) in their fields. BARI obtained a GM technology from an Indian company (Mahyco) and developed several new brinjal varieties (Bt-brinjal), which are resistant to the FSB insects. India, the Philippines and Bangladesh started working on the development of Bt-brinjal in the early 2000s and only Bangladesh got approval for the commercial production of Bt-brinjal in 2013. Bangladesh is one of the first developing countries to grant regulatory approval of a GM crop. The first section of this chapter helps to understand the development process of Bt-brinjal in Bangladesh.

The second section provides a brief discussion of social license. The definition of social license may differ from a developed and developing country perceptive. Several definitions of social license are provided in this section in a Canadian agricultural context. In a developed country context, social license is more about public trust, and often revolves around discussion about consumers/public "right to know" how food is produced. There is no exact definition of social license found in a developing country context. Thus, this study seeks to determine how social license can be evaluated in a developing country context.

The third section provides an overview of a selection of literature examining stakeholders' interest, views and perceptions towards technology adoption (especially genetically modified crops). Stakeholders are different in nature to each other. Government is responsible to build biosafety rules and regulations before introducing any biotechnological application. Thus, developer groups have a direct connection to government. Other stakeholders including consumers, producers, NGOs, civil society and media also have an influence in the adoption process of a new technology. This section helps to determine what factors are expected to have an influence in establishing social license and inform the development of a conceptual model of social license.

The last section presents a proposed conceptual model of social license. There is no exact measurement for social license. Thus, willingness to accept is used to indicate how social license can be evaluated. This conceptual model informs the empirical analysis of social license conducted in this study.

Chapter 3 Survey Design and Descriptive Analysis

3.1 Introduction

The objective of this study is to identify the factors that affect social license in adopting Bt-brinjal in Bangladesh and who are the key stakeholders in establishing social license for Bt-brinjal. In chapter 1, a research question was posed: what are the main drivers of social license and who are the key stakeholders involved in establishing social license for the adoption of Bt-brinjal in Bangladesh. The research results of a study largely depend on its methodology. This chapter explains how the surveys conducted for this study were designed with respect to fulfilling the research objective and presents descriptive statistics for the survey data. This chapter is organized as follows: a brief discussion of survey design for data collection is provided in section 3.2, followed by the descriptive analysis of the survey data (section 3.3). Conclusions to the chapter are provided in section 3.4.

A behavioural ethics application was submitted to the University of Saskatchewan Behavioural Research Ethics Board (BEH 17-47) on February 7, 2017. An exemption letter was received from Behavioural Research Ethics Board on February 14, 2017 and is available in Appendix 1. The behavioural ethics application was exempted because it meets the exemption status as per **Article 2.5** of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans, December 2014.[4]

3.2 Research Methodology

This section explains the survey design, selection of study area and how the data were collected from the selected areas. It also explains how the data sets were prepared for the final analysis**.**

3.2.1 Questionnaire Design

Before designing the surveys for this study, literature on people's perceptions of and attitudes towards new agricultural technologies was reviewed. A simple questionnaire was designed separately for various stakeholders. The literature shows that producers, non-producers,

[4] The behavioural ethics application was exempted because it is stated on article **2.5** of the TCPS that "quality assurance and quality improvement studies, program evaluation activities, and performance reviews, or testing within normal educational requirements when used exclusively for assessment, management or improvement purposes, do not constitute research for the purposes of this policy, and do not fall within the scope of REB review."

consumers, developers, other NGOs and civil society groups play a significant role in the development process of GM crops in agriculture. Thus, three separate questionnaires were designed to collect data from Bt-brinjal farmers (adopters), non-Bt brinjal farmers (non-adopters) and consumers. Since other stakeholders also play a key role in the adoption process of Bt-brinjal, key questions were outlined for interviewing the representatives of relevant institutions (government, research) and individuals from NGOs or civil society groups. Attention was given to the general form of the questionnaires to see that all the questions followed a logical and appropriate sequence.

Bt-brinjal farmers are one of the most important stakeholders in the adoption process. Thus, this study places more emphasis upon the adopter survey than the other surveys. The adopter survey questionnaire consists of eight sections. Section A includes a set of questions related to general farming information about Bt-brinjal. Section B includes a set of questions about farming and marketing information. Section C includes a set of questions related to Bt-brinjal and non-Bt brinjal production practices. Section D includes a set of questions related to knowledge of Bt-brinjal. Section E includes a set of statements about perceptions of and attitudes toward Bt-brinjal. Section F includes a set of questions related to the relationship with developer groups and Department of Agricultural Extension (DAE) officials. Section G includes a set of questions related to willingness to adopt Bt-brinjal and the concluding section H consists of socio-demographic questions. A copy of the adopter survey is available in Appendix 2. The non-adopter survey is relatively similar to the adopters' survey questionnaire, except for questions regarding Bt-brinjal production, which are excluded from the survey questionnaire since the non-adopters do not have experience of Bt-brinjal production. The non-adopter survey questionnaire provides a brief explanation of Bt-brinjal to the respondents to examine the willingness to adopt Bt-brinjal if Bt-brinjal seeds are available to them. A copy of the non-adopter survey is available in Appendix 3.

The consumer survey questionnaire consists of five sections, where section A includes a set of questions related to general information about their food shopping, especially brinjal purchase information. Section B includes a set of questions related to knowledge of Bt-brinjal. Before approaching section C, a brief explanation of it is also provided to the consumers to evaluate their willingness to buy Bt-brinjal if Bt-brinjal is available in the local market. Section D includes a set of statements regarding perceptions of and attitudes toward Bt-brinjal and lastly, section E consists of socio-demographic questions. The consumer survey is available in Appendix 4. All questionnaires have a common section, which includes a set of statements regarding the perception of and attitudes towards Bt-brinjal on a five-point Likert scale, where 1 represents strongly disagree and 5 represents strongly agree.

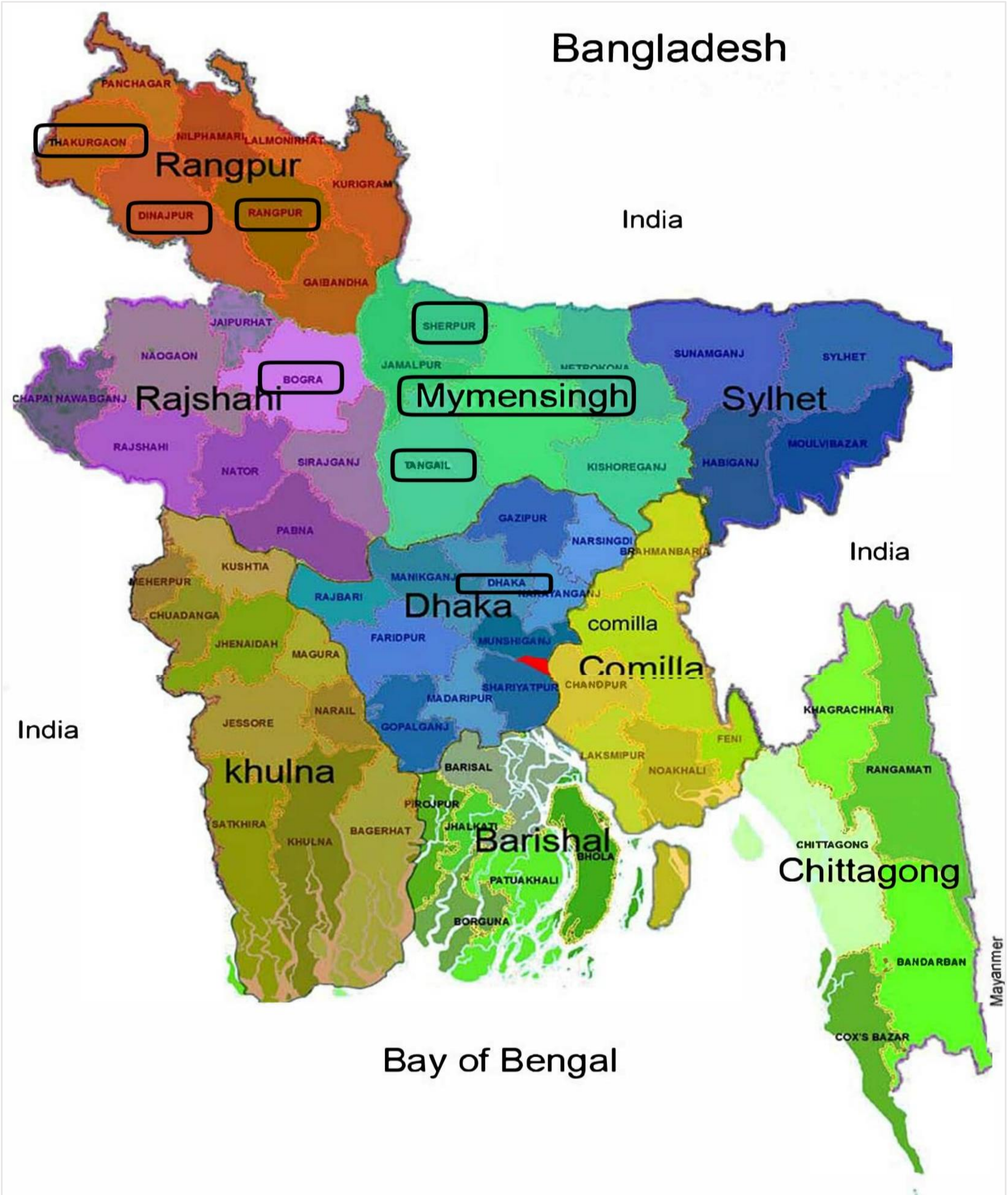
3.2.2 Selection of Study Area

The justification for focusing on Bt-brinjal in Bangladesh is provided in chapter 1. While Bangladesh has been selected as the study area, it was impractical to cover the whole country. Therefore, a formal meeting with a principal scientific officer in the department of On-farm Research Division, Bangladesh Agricultural Research Institute (BARI) was held in March 2017 to select specific locations for collecting data. As a very new GM crop, there is a lack of technical know-how about Bt-brinjal in Bangladesh. Research on this crop is still ongoing. Public awareness is mostly absent or only present to a limited extent. Everyday new knowledge emerges in the field of biotechnology, but the process of dissemination is very slow in Bangladesh. Thus, people have limited knowledge about Bt-brinjal. Therefore, the selection of study areas was made considering specific criteria of those locations. The time available for data collection was finite and was a factor in the selection of these areas. The selection of study areas was made based on a number of considerations, including:

i. Bt-brinjal producing areas in Bangladesh.
ii. Availability of information about Bt-brinjal production
iii. The possibility of getting reliable data from the respondents.
iv. Easy accessibility and transportation system

Considering all the above points, 7 districts in Bangladesh were selected to collect data for this study. The districts are: Mymensingh, Tangail, Sherpur, Bogra, Rangpur, Dinajpur and Thakurgaon. Figure 3.1 shows a map of Bangladesh indicating the study areas. Table 3.1 shows the list of participants who were interviewed from each district. The consumer survey was not limited to a specific location. A consumer survey was done in several marketplaces during the period of data collection for the adopters and non-adopter surveys. Dhaka is the capital city of Bangladesh and 4 consumers were interviewed from Dhaka city (see Table 3.1).

Figure 3.1 Map of Bangladesh indicating study areas



Source: http://www.mediabangladesh.net/map-of-bangladesh/

Table 3.1: List of participants in each district in Bangladesh

Districts	Adopters	Non-adopters	Consumers
Mymensingh	6	5	8
Sherpur	7	8	1
Tangail	13	2	0
Bogra	16	16	6
Rangpur	12	7	3
Dinjalpur	10	5	4
Thakurgaon	1	4	4
Dhaka	0	0	4
Total	65	47	30

3.2.3 Data Collection

To achieve the objective of this study a primary survey was conducted in various locations in Bangladesh. In any research, data collection is a necessary step, either it is primary or secondary data. The success of any study depends on the accuracy and reliability of the collected data that depends on the method of data collection. The data were collected from primary sources and was accomplished by direct interviews with the randomly selected respondents. However, Bt-brinjal farmers were informed before interviews through district regional BARI offices and selection was made randomly among the available Bt-brinjal farmers once the researcher reached the village. Non-adopters were selected randomly from those brinjal farmers who do not have experience of Bt-brinjal production practices. Thus, the study areas were selected purposively with the assistance of district regional BARI offices. Data were collected during the months of March and April 2017.

As it was somewhat challenging to collect data within a short period of time, two enumerators were hired to assist with data collection. Specific skills and abilities were considered in case of hiring enumerators, including master students in agriculture and preference were given to those with prior experience of survey data collection. The researcher provided a training session to the enumerators about the objectives of this study and the data collection process.

To facilitate timely and relevant data collection, the researcher contacted various regional offices of BARI. BARI is the developer of Bt-brinjal in Bangladesh and is directly involved in the technical transfer of Bt-brinjal in Bangladesh. According to the BARI officials, Bt-brinjal farmers are still part of the field trials within the technology transfer process. Therefore, they have the contact information of all farmers who are currently growing Bt-brinjal in various locations. In the last cropping season, more than 500 farmers grew Bt-brinjal with the assistance of BARI officials. Thus, BARI assisted in identifying the potential respondents for the Bt-brinjal adopter and selection was made randomly among the available Bt-brinjal farmers from each village. Therefore, the researcher used a snowball sampling technique to select the adopters (Bt-brinjal growers), as well as non-adopters for this study. A snowball sampling technique is a non-probability sampling technique, which is used to select specific respondents while it is hard to find the locations of the respondents. Thus, the sample size of this study is small and non-random, and the results should be interpreted in the context of this caveat.

Before beginning the face-to-face interview, a brief idea about the nature and purpose of this study was given to the respondents. A few procedures were implemented to control the quality of the survey data. Screening questions were asked first in every survey questionnaire. For example, for the adopters and non-adopters survey, the first question was: "Are you a regular (non-Bt) brinjal producing farmer?" Respondents answering "Yes" means proceeded to the next question. Another screener question for both surveys was "Do you grow Bt-brinjal?" Respondents who answered "Yes" were administered the adopter survey and those who answered "No" were given the non-adopter survey. The consumer survey also incorporated screener questions. Consumers who had not previously purchased brinjal did not proceed to the next question and were excluded from the survey.

Data were imported to excel spreadsheets as early as possible after face-to-face interviews. Three separate spreadsheets were prepared for each survey questionnaire. All qualitative data were converted into a quantitative type by coding them into the excel sheets. Finally, all tabulated data were initially analyzed using simple statistical techniques such as mean, standard deviation, percentage and graphs. An incomplete survey questionnaire found in the adopter survey during the data-cleaning period was removed from the whole dataset. Therefore, a total of 64, 47 and 30 usable questionnaires for the adopter survey, non-adopter survey and consumer survey respectively were retained for the final dataset. This study uses a multinomial logit model to analyze the datasets (adopters and non-adopters data). As this study used snowball sampling to select respondents, and given the small sample size, caution should be exercised in extrapolating these results given the potential presence of bias due to small, non-random sample.

3.3 Descriptive Data Analysis

This section provides a descriptive analysis of the data set for each survey and consists of three parts: a descriptive analysis of the adopter survey (3.3.1); the non-adopter survey (3.3.2) and the consumer survey (3.3.3).

3.3.1 Adopter Survey

3.3.1.1 Socio-demographic Characteristics of the Adopters

A set of socio-demographic questions were asked to the respondents at the end of the survey. More than 90% of respondents were male, as depicted in Figure 3.2. The average age of the adopters is 42.26 years.

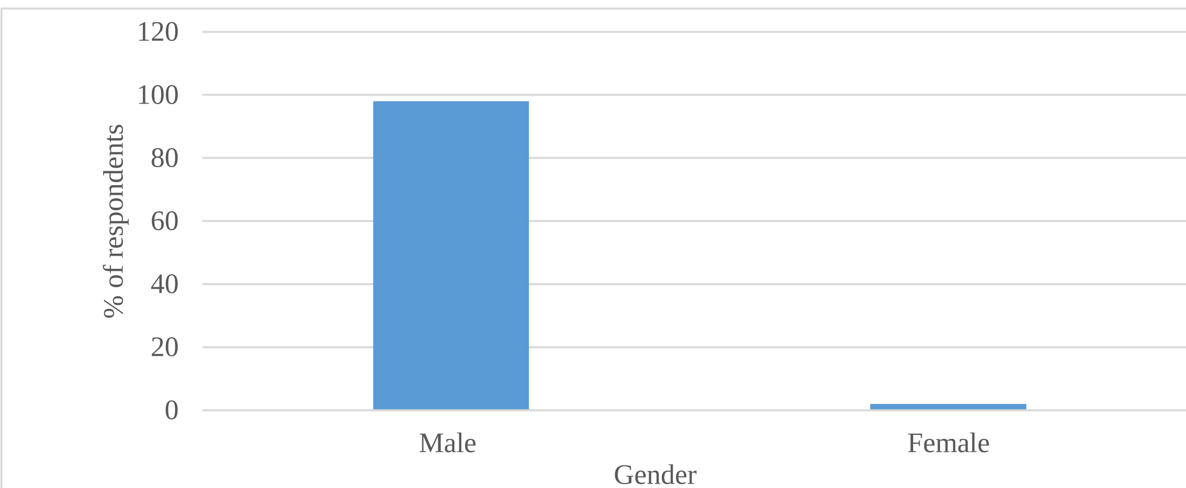


Figure 3.2: Gender of adopters

Figure 3.3 shows that a higher percentage of respondents have a secondary level of education. Around 20% of the respondents do not have any education while only 3% went to university. Questions regarding farm size, off-farm occupation and annual income were also asked and show that 37.5% respondents have off-farm income. Average farm size found in the adopter survey is 0.97 hectares. Farm size was calculated by adding total own land area and total rented area. The income data suffered from missing information. Bangladeshi marginal farmers do not typically keep records of annual income. Thus, the collected data for annual income varied significantly from one response to another and may not be reliable. Therefore, income data are not reported here.

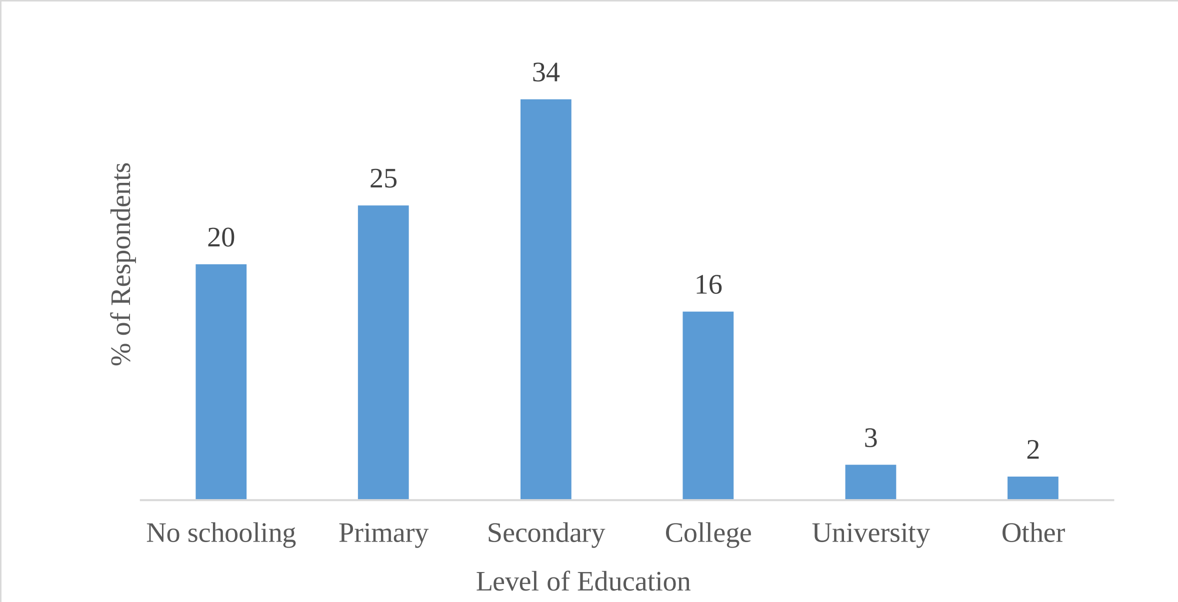


Figure 3.3: Level of education of adopters

3.3.1.2 General Farming and Marketing Practices of the Adopters

To obtain a clear idea about the farming and marketing systems of vegetable production, a set of questions were asked. Participants were asked: “How often do you grow vegetables?” Figure 3.4 shows that 67.19% of respondents grow vegetables all the year round while 32.81% like to grow mostly in the winter season. Bangladeshi vegetable farmers mostly grow vegetables in the winter season because of the favourable weather conditions for vegetable production.

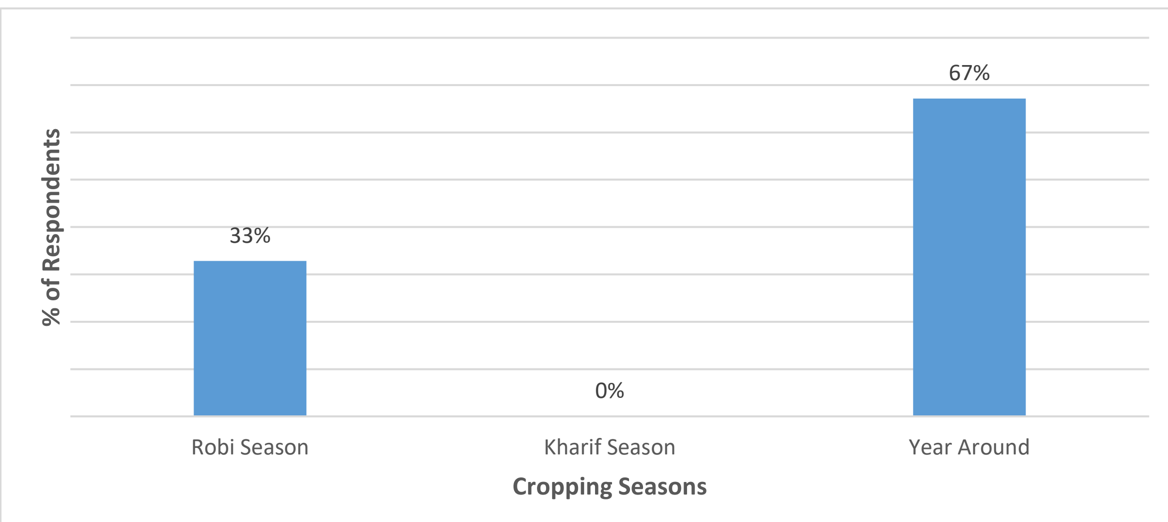


Figure 3.4: Cropping seasons: Adopter survey

Bangladeshi vegetable farmers produce various kinds of vegetables. Figure 3.5 shows the percentage of the sample population producing various vegetables. More than 90% of respondents produce potato and brinjal as their main vegetables, while 95.31% of respondents produce other vegetables, for example Indian spinach, red amaranth/lalshak, pointed gourd/potol, orka, dantashak, radish, green banana, green papaya, bitter gourd/karola, kachu/eddoes. A set of questions were also asked about the production of other crops besides vegetable production. Other potential crops grown by the vegetable farmers are rice, wheat, maize and jute (see Figure 3.6). Rice is one of the major crops in Bangladesh, therefore, more or less every farmer in Bangladesh produces rice in their field. Thus, data shows that around 96.88% of respondents are also involved in rice production. A question was asked about the proportion of vegetables that adopter farmers use for family consumption and selling in the market. Respondents on average sell more than 90% of the produced vegetables in the market, with the remainder used for household consumption. Typically, farmers in Bangladesh do not keep records about what percentage of their produced vegetables was sold in the market.

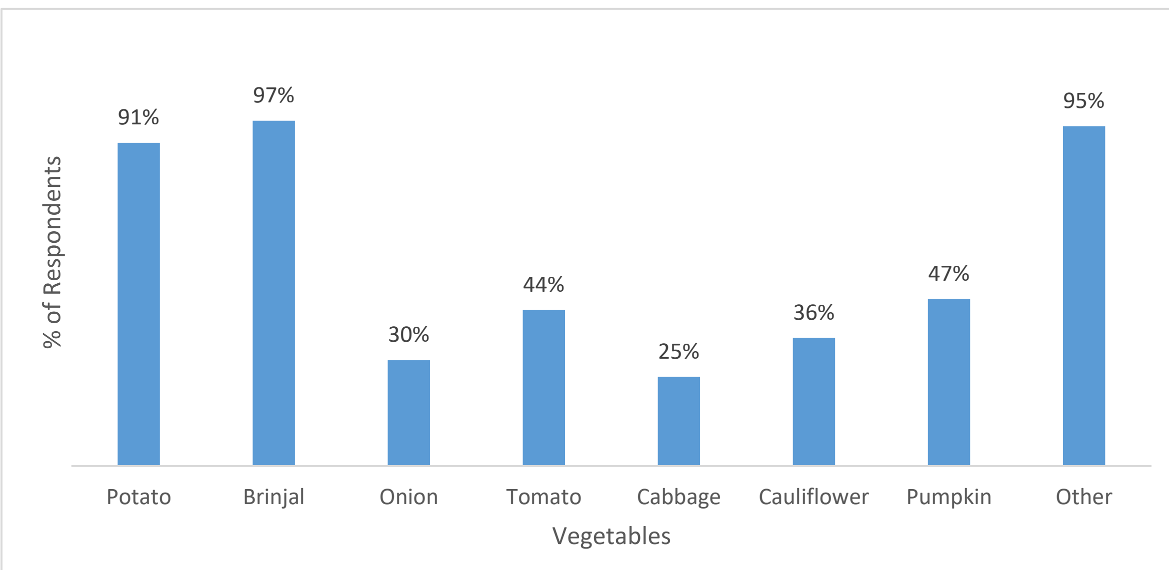


Figure 3.5: Major vegetables grown by Bt-brinjal adopters

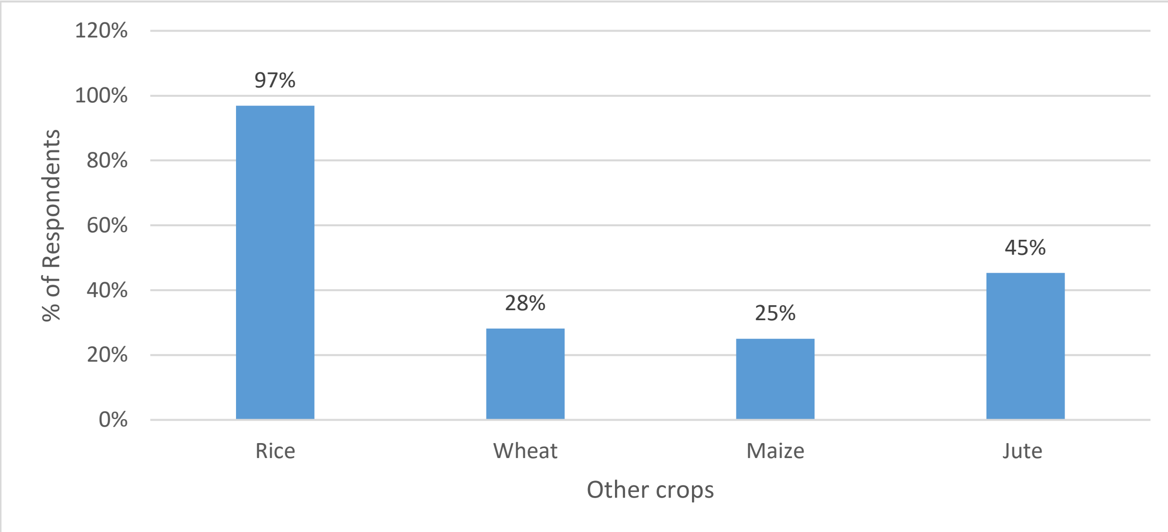


Figure 3.6: Other crops grown by Bt-brinjal adopters besides vegetable production

Bangladeshi farmers use various varieties of seeds for vegetable production. Figure 3.7 shows that 15.63% of respondents are solely dependent on hybrid varieties while 81.25% of respondents rely on both hybrid and open pollinated varieties of seeds. However, more than 80% of farmers mentioned that they use both varieties of vegetable seeds. The farmers who use both varieties of vegetable seeds also indicated that the percentage of using hybrid seeds is higher than OPV seeds.

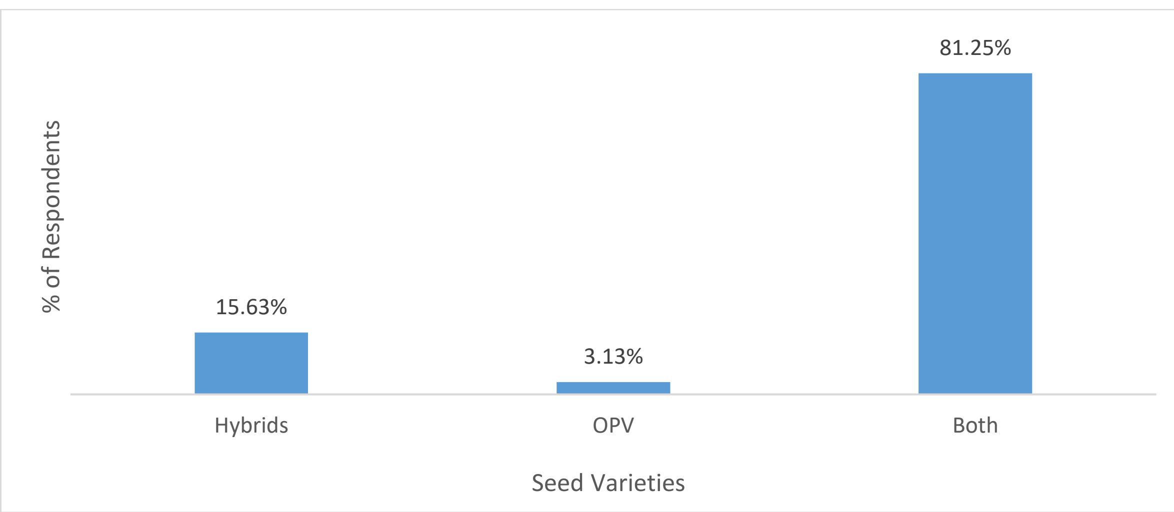


Figure 3.7: Use of hybrid and open-pollinated varieties: Adopter survey

Questions on sources of vegetable seeds were also asked to the respondents. The answer was categorized into various sources. Figure 3.8 shows that a higher percentage of the sample population buy vegetable seeds from local dealers. In this study, local dealers are defined as those who sell different varieties of vegetable seeds (both hybrid and OPV varieties) and who also connected with various private seed companies. Farmers also specified that they use their own processed (saved) seeds for vegetable cultivation. Sometimes farmers themselves reserve seeds from the previous year of cultivation and process the seeds for the next cropping year. Therefore, an additional answer category (own seeds) was added in tabulating the data.

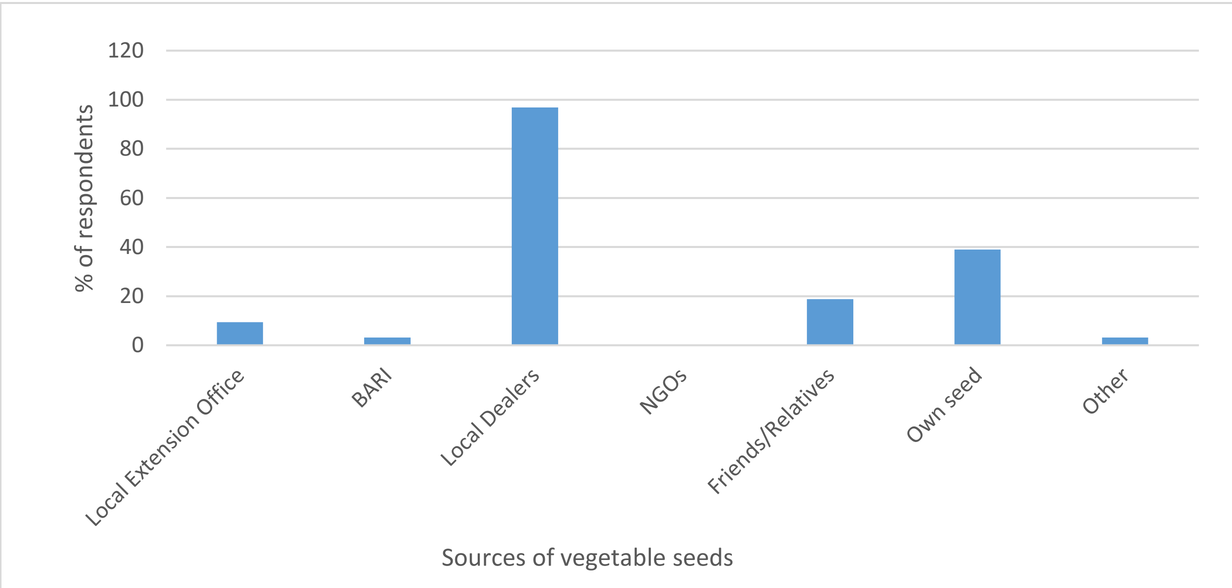


Figure 3.8: Sources of vegetable seeds (Adopter survey)

The supply chain of vegetables from farmers to consumers is not the same for each farmer. Small farmers mostly sell vegetables directly to the local market. Directly selling in the local market means farmers sell their product directly to consumers in the local village market. Directly selling in the city/town market means that farmers themselves carry their product to the city/town market and sell the products directly to consumers. A significant percentage of farmers tend to sell vegetable through commission agents. Commission agents are those intermediaries who buy the vegetables directly from farmers and sell them in the city/town market. Figure 3.9 shows that 90.63% of adopters sell vegetables through commission agents.

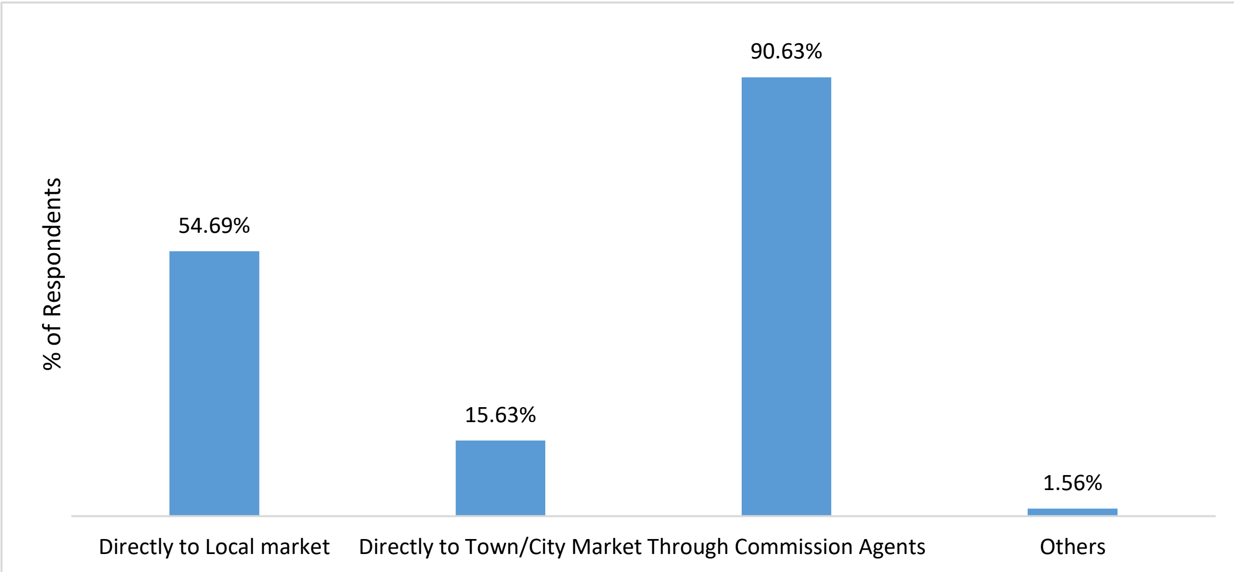


Figure 3.9: Marketing channels for selling vegetables (Adopter survey)

3.3.1.3 Production Practices of Bt-brinjal: Adopter Survey

The screener question in the adopter survey ensured that among all the adopters, around 95.31% of respondents have experience of non-Bt brinjal production. Bt-brinjal was commercialized in 2013 and farmers started growing the crop in 2014. Adopter farmers have been producing non-Bt brinjal on average for 8.57 years, while the average length of time producing Bt-brinjal is 1.31 years.

Several questions were asked to the respondents about their most recent cropping year experiences for both Bt-brinjal and non-Bt brinjal production. In Bangladesh, the common unit of measurement for agricultural land area is known as a decimal, which is the lowest unit. The data were first collected on a decimal unit and then converted into hectares (ha). Although 95.31% of adopters claim themselves as non-Bt brinjal growing farmers, the data shows that in the last cropping year only 48 adopters grew non-Bt brinjal and Bt-brinjal at the same time. Table 3.2 shows a summary of non-Bt brinjal production by the adopters. The average land for brinjal production on the adopter farms was 0.078 ha (see Table 3.2). Almost all 48 farmers found the FSB insect in their non-Bt brinjal fields. Participants were also asked: “Have you sprayed pesticides for the FSB insect?” Table 3.2 shows 47 respondents used pesticides to control the FSB insect. The average number of pesticide application is 28.6 over a whole season. In Bangladesh, there are 103 varieties of brinjal. Thus, farmers produce various varieties of brinjal in Bangladesh. Respondents also claimed not only the FSB insect but also other pests attack the brinjal plants. A question was asked about the total cost of pesticides during a whole season. Among 48 farmers, 39 of them reported the cost of pesticide spraying, which is on average BDT 6346.35. This estimated average cost was the total pesticide cost to control the FSB and other insects for the non-Bt brinjal production only.

Table 3.2: Non-Bt brinjal production by adopters

Questions	Units	Minimum	Maximum	Average/Total
The total land area that you used for brinjal production in the last season.	**Hectare (ha)**	0	0.81	0.078
Do you find the fruit and shoot borer (FSB) insect in your brinjal fields during the last season?	**No of respondents**	-	-	48
Have you sprayed pesticides for FSB insect over the season?	**No of respondents**	-	-	47
How many times have you sprayed pesticides to control the FSB insect over the last season?	**No. of pesticide application**	0	65	28.60
Did you find any other pests in brinjal fields over the last season?	**No of respondents**	-	-	41
How many times have you sprayed pesticides to control other pests over the last season?	**No. of pesticide application**	0	32	4.83

Table 3.3 provides information about Bt-brinjal production. Respondents used 0.051 ha of land on average for Bt-brinjal production in the recent cropping season. There was no FSB insect infestation in Bt-brinjal fields and they did not use pesticides in their Bt-brinjal field. Adopters claimed that Bt-brinjal has no FSB insect infestation at all but Bt-brinjal plants get attacked with other pests easily, for example whitefly. Adopters claimed that Bt-brinjal plants need more care than non-Bt brinjal, for example, it needs a better drainage system for watering. Bacterial wilting is also another problem found in Bt-brinjal fields recently and had become a major problem in Bt-brinjal production. Bacterial wilting is a disease and it happens very suddenly. Respondents were also asked about the cost of Bt-seeds and reported that they got the Bt-brinjal seeds from BARI for free.

Table 3.3: Bt-brinjal production by adopters

Questions	Units	Minimum	Maximum	Average/Total
Total land area that you used for Bt-brinjal production in the last season	**Hectare (ha)**	0.016	0.12	0.051
Do you find the fruit and shoot borer (FSB) insect in your Bt-brinjal fields during the last season?	**% of respondents**	-	-	2
Have you sprayed pesticide to control FSB insect?	**% of respondents**	-	-	0
How many times have you sprayed pesticide to control FSB over the season?	**No. of pesticide spraying**	-	-	0
Did you find any other pests in Bt-brinjal fields?	**% of respondents**	-	-	98
How many times have you sprayed pesticide to control other pests over the last season?	**No. of pesticide spraying.**	0	30	7.70

According to the survey data, the average total number of pesticide applications for non-Bt brinjal production in a season is 33.43 (28.60+4.83) for all types of pests, while Bt-brinjal producers, on average, used only 7.70 pesticide applications in a season (see Table 3.2 and Table 3.3). An estimation was done to calculate the average cost saving in pesticide use against the FSB insect from Bt-brinjal production. The average cost per pesticide application is estimated at approximately BDT 190 (CAD ~$3) for non-Bt brinjal production per season[5]. Thus, the average cost of pesticide use against the FSB insect is BDT 5434 (BDT 190 *28.60 applications) for non-Bt brinjal production. Table 3.2 shows that there are no pesticide applications needed to control the FSB insect in Bt-brinjal fields. Therefore, it is assumed that the average cost saving in pesticide use is BDT 5434 (CAD ~$83) per season from Bt-brinjal production. It should be noted that these are rough estimates given the considerable range in reported number of pesticide applications and costs within the survey data.

[5] The average cost of pesticide use per application= the total cost of pesticide use in a season/total number of pesticide applications in a season. Here, using the data from non-Bt brinjal production, across the sample as a whole the total cost of pesticide was on average BDT 6346.35 per season and total number of pesticide application was on average 33.43 per season. Thus, the average cost of pesticide use per application is 190 (BDT 6346.35/33.43= 189.83~190).

3.3.1.4 Sources of Information about Bt-brinjal (Adopter Survey)

A question was first asked to the respondents about the sources of information for new crop varieties in general. Figure 3.10 shows that 73.44% of respondents get information from BARI about new crop varieties. A high percentage of respondents get knowledge about new crop varieties from BARI because they have regular contact with BARI as Bt-brinjal growers. Therefore, they are more likely to get information about new technology from BARI than other sources. Other sources also have importance to provide information about new crops, particularly local dealers and extension services.

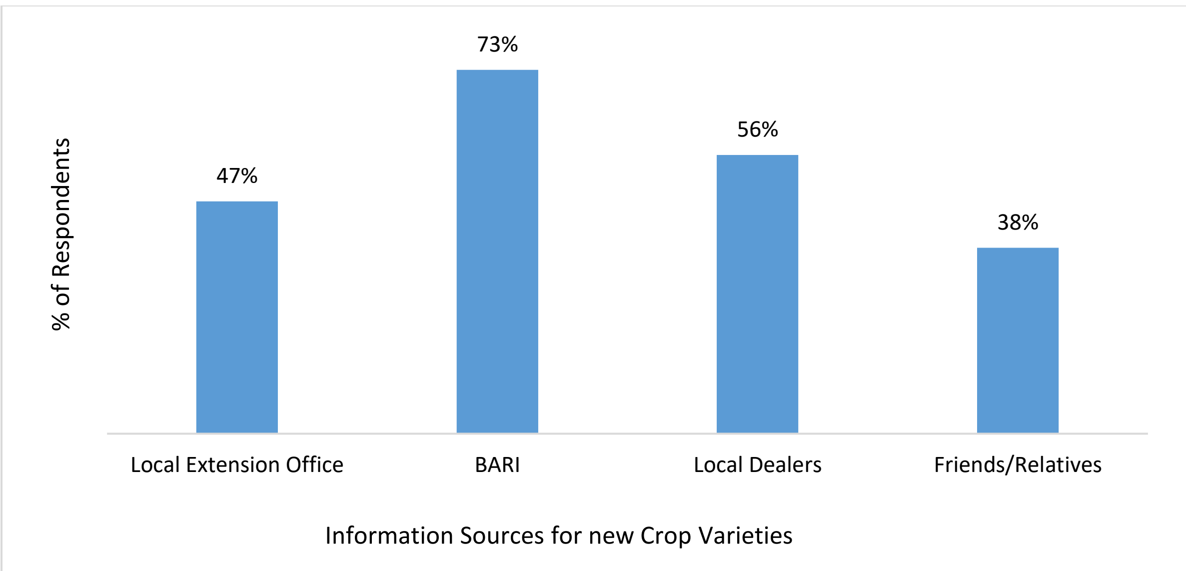


Figure 3.10: Information sources about new crop varieties (Adopter survey)

A question was also asked to respondents about their sources of information for Bt-brinjal. The data shows that the primary source of information about Bt-brinjal is BARI, where very few respondents first heard about Bt-brinjal from their neighbour farmers/relatives (see Table 3.4). Respondents were also asked: “From where you normally get Bt-brinjal seeds?” Potential responses were Local Extension office, Bangladesh Agricultural Research Institute (BARI), local dealers, NGOs, friends/relatives and others. BARI is the developer of Bt-brinjal in Bangladesh and they are providing all of the necessary inputs to the adopters for its production. Therefore, adopters primarily get Bt-brinjal seeds from BARI offices while very few of them also get Bt-brinjal seeds from local extension offices (3%) and their friends/relatives (9%) (See Figure 3.11). Figure 3.11 excludes local dealers and NGOs because the percentage of respondents was zero for these categories.

Table 3.4: Source of information about Bt-brinjal (Adopter survey)

Sources	No of respondents	% of respondents
Local Extension Office	6	9.38
BARI	64	100.00
Local Dealers	0	0.00
NGOs	0	0.00
Friends/Relatives	9	14.06
Others	0	0.00

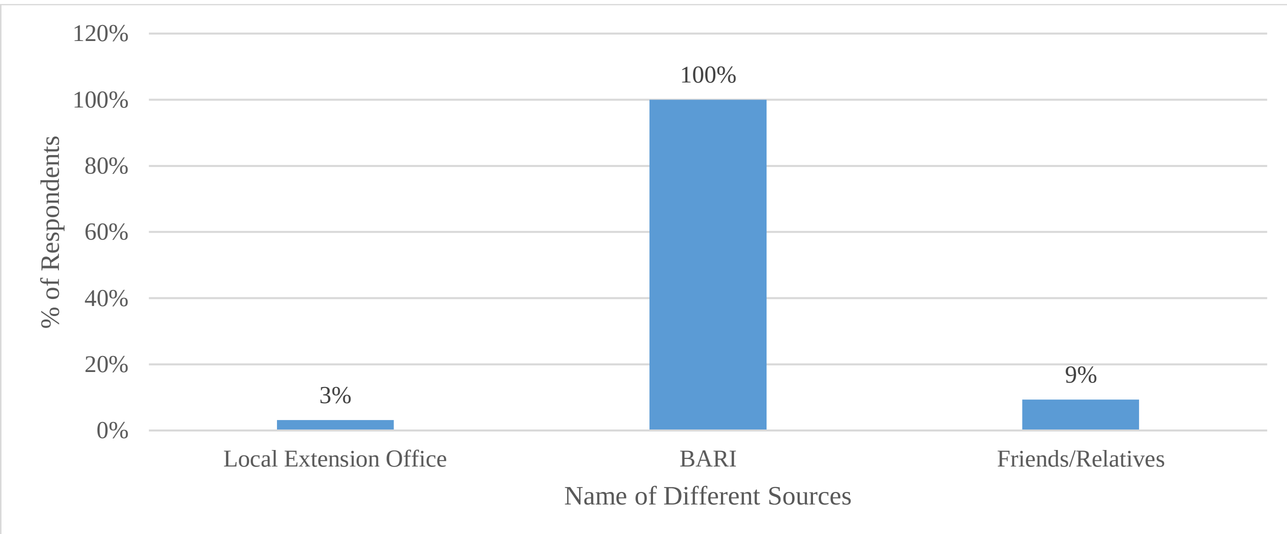


Figure 3.11: Multiple sources of Bt-brinjal seeds (Adopter survey)

3.3.1.5 Level of Knowledge about Bt-brinjal (Adopter Survey)

To examine the level of knowledge about Bt-brinjal, a 5 point Likert scale was used, where 1 represents not at all knowledgeable and 5 represents very knowledgeable. Figure 3.12 shows that around 17.19 percent of respondents claim to be moderately knowledgeable. No one claim to be a very knowledgeable person about Bt-brinjal. The highest percentage (67.19%) regraded themselves as somewhat knowledgeable.

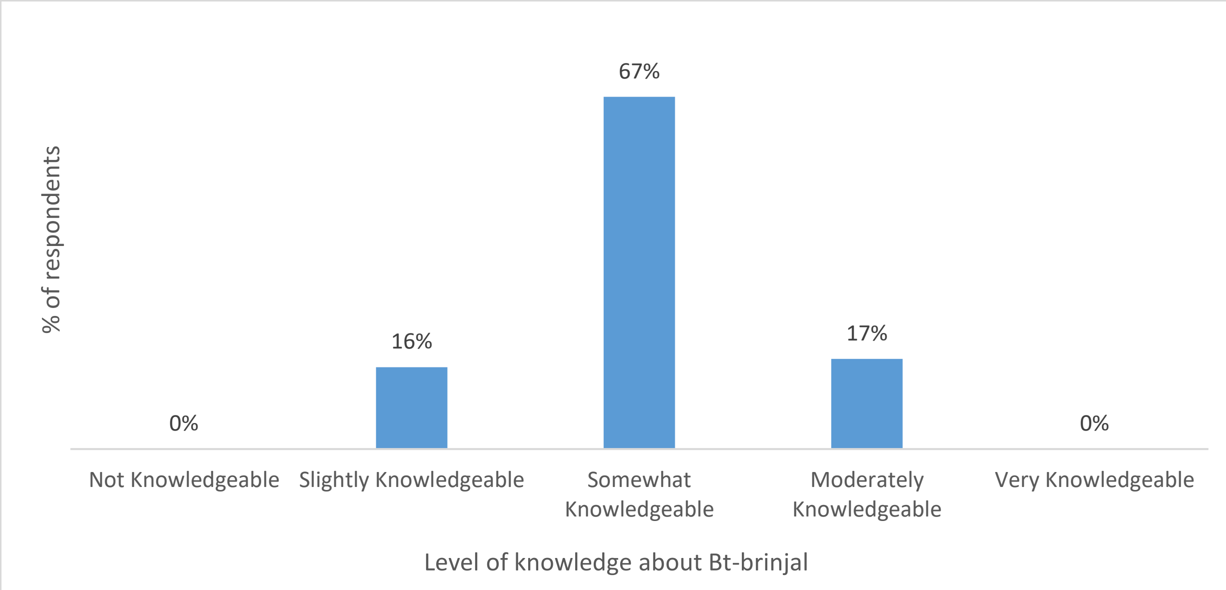


Figure 3.12: Adopters knowledge about Bt-brinjal

3.3.1.6 Perceptions of Bt-brinjal (Adopter Survey)

A question about the importance of biosafety rules and regulations regarding the adoption process of Bt-brinjal was asked to the adopters. Table 3.5 shows that 75% of the sample population agreed that biosafety rules and regulations play a significant role in the adoption process of Bt-brinjal, while 25% of them are not sure about the biosafety rules and regulation, which suggest that they do not have knowledge about the biosafety rules and regulation.

Table 3.5: Perceived importance of biosafety rules and regulations (Adopter survey)

Questions	Responses	No. of respondents	% of respondents
Do you think that Biosafety rules and regulations play a significant role in the adoption process of Bt-brinjal?	Yes	48	75
	No	0	0.0
	Not sure	16	25

Six statements were prepared to examine the perceptions of and attitudes towards Bt-brinjal among adopters. An ordered scale of 1 to 5 was used, where 1 means “strongly disagree” and 5 means “strongly agree”. Figure 3.13 shows that a large proportion of respondents strongly agree with all the statements except the second statement: “The yield of Bt-brinjal is greater than the non

Bt-brinjal in your field." Adopters also claim that the yield of Bt-brinjal varies from one variety to another.

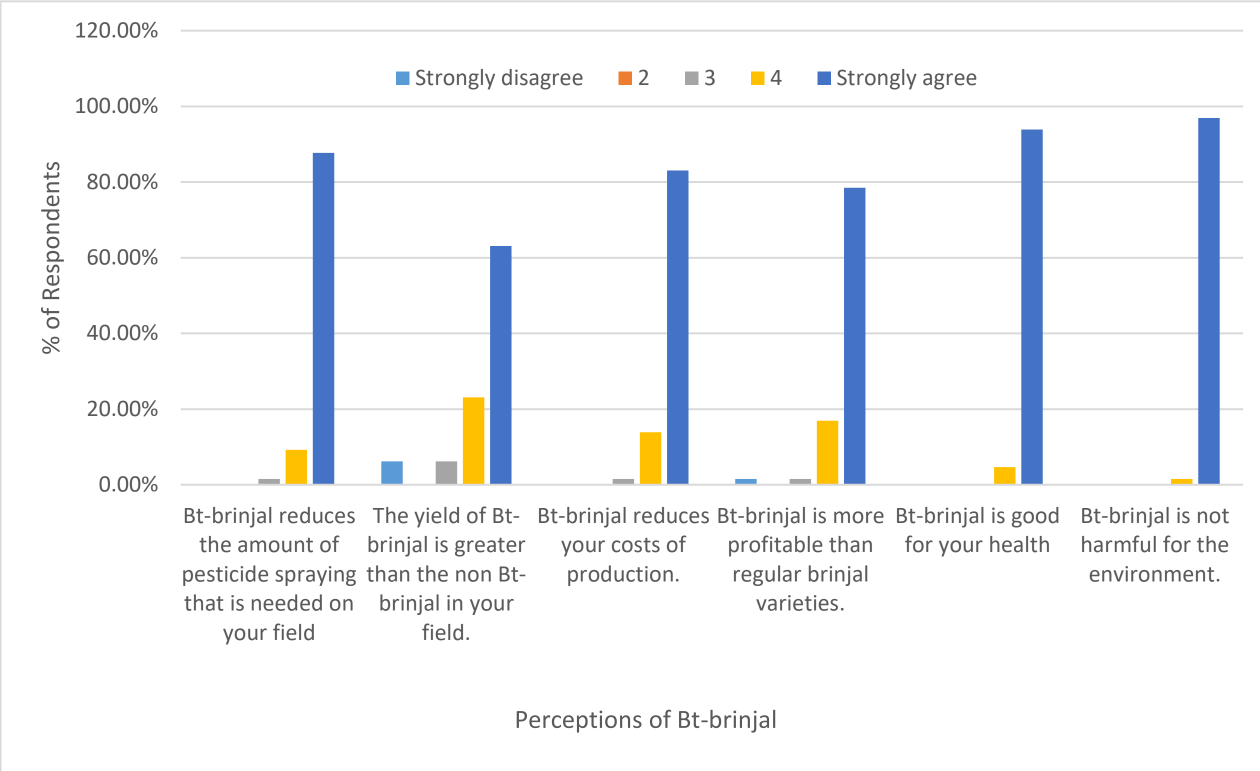


Figure 3.13: Perceptions of Bt-brinjal (Adopter survey)

3.3.1.7 Relationships with BARI and DAE Individuals

Bangladesh Agricultural Research Institute (BARI) plays a central role in the development and technical transfer of Bt-technology in Bangladesh. The survey data confirmed that BARI provides all input supplies including seeds, pesticides, fertilizers and other miscellaneous input costs to the Bt-brinjal farmers. Farmers only need to provide the labour cost to produce Bt-brinjal. Almost all respondents have direct contact with BARI individuals. Respondents were asked to rate BARI on a 1 to 5 scale where 1 indicates "not at all important" and 5 indicates "very important". The survey data shows that all (100%) of the respondents rated BARI as a very important source regarding Bt-brinjal production. As a new variety, adopters are completely dependent on BARI about the nature of this crop because BARI is responsible for the development of this new brinjal variety. Thus, a question was also asked to respondents: "How often do BARI researchers visit Bt-brinjal fields?" Figure 3.14 shows a higher percentage (56.45%) of respondents claim that BARI researchers frequently visit their crop, while 35.48% report very frequent visits.

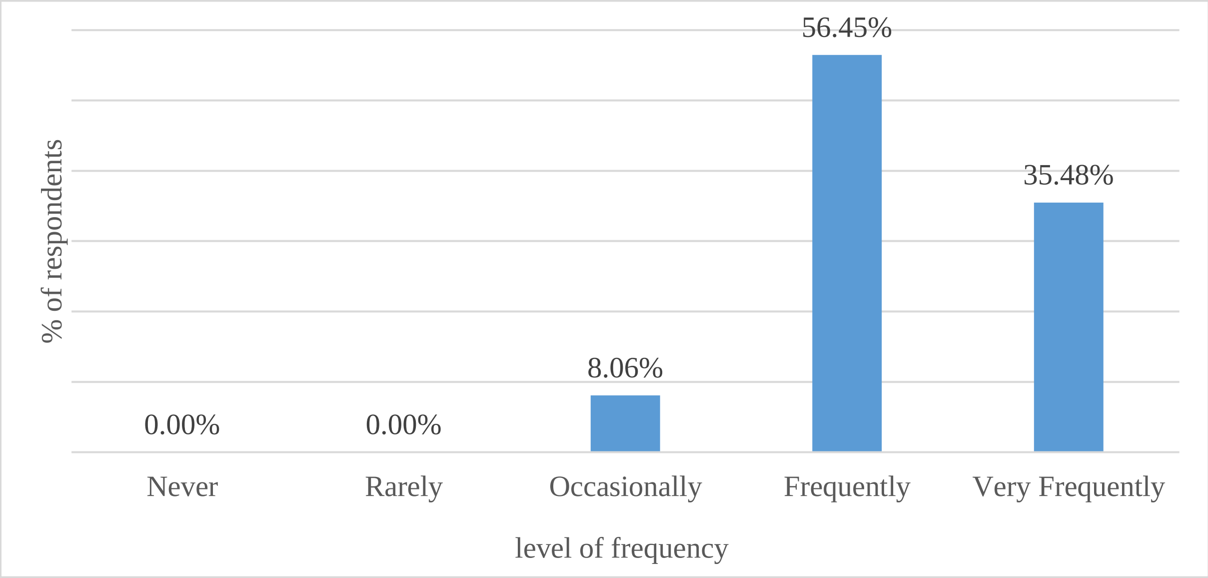


Figure 3.14: Bt-Brinjal field visits by BARI researchers

Recently the Department of Agricultural Extension (DAE) started providing Bt-seeds to farmers. This study was not able to capture those adopters who get Bt-brinjal seeds from DAE. The DAE provides services to all categories of farmers to increase the sustainable and profitable crop production. Therefore, DAE also plays a significant role in the extension of Bt-technology among farmers. Approximately 20% of the adopters who get Bt-seeds from BARI offices also have contact with DAE individuals. DAE does not provide financial support but helps the adopters through technical advisory (extension) services.

3.3.1.8 Willingness to Adopt Bt-brinjal (Adopter Survey)

Adopters were asked about their willingness to adopt Bt-brinjal if Bt-seeds were available to them. The survey revealed a high rate of acceptance among adopters with a strong willingness to adopt Bt-brinjal. Figure 3.15 shows that 93.75% of respondents indicate that they are willing to adopt Bt-brinjal. A possible bias could be the reason for the very high proportion of the sample indicating a willingness to adopt because most of the adopters from whom the data were collected are part of a Bt-technology transfer project with BARI. Given the context, this question may be subject to agreement bias.

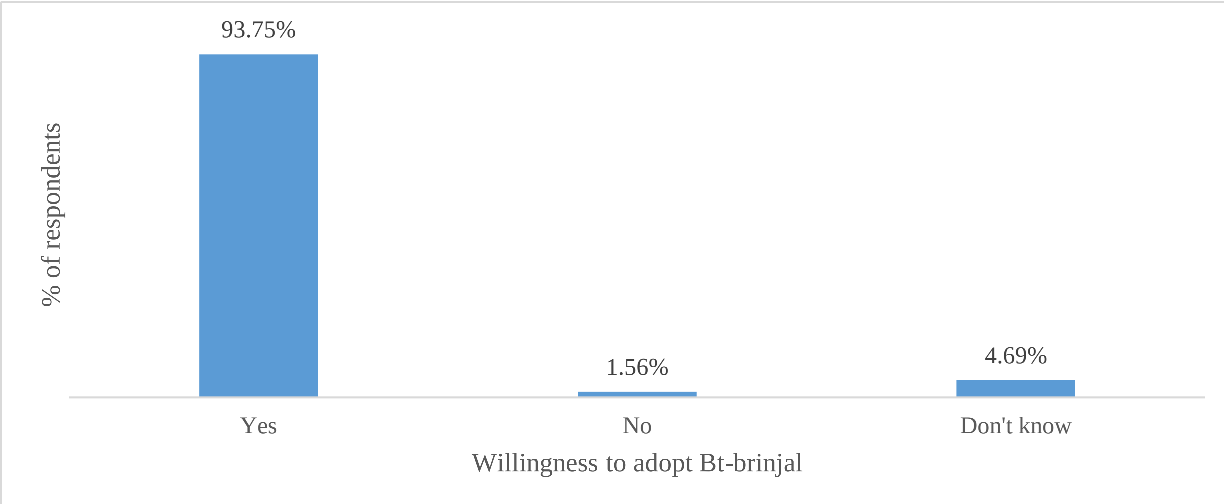


Figure 3.15: Willingness to adopt Bt-brinjal (adopter survey)

Respondents were also asked to indicate the most important reason for their willingness to adopt Bt-brinjal in the future. Six reasons were provided in the questionnaire and respondents were asked to pick one most important reason as their main motivation for being willing to adopt Bt-brinjal. Figure 3.16 shows that less FSB insect infestation was the primary reason, followed by marketable yield is greater than non-Bt brinjal, and fewer pesticide use in the field. A higher percentage (39%) of respondents claim that if Bt-brinjal has less FSB insect infestation, they are more likely to adopt Bt-brinjal, while 27% and 19% of respondents picked marketable yield is greater than non-Bt brinjal, and less pesticide use respectively. Only 2% of respondents claim that they are more likely to adopt Bt-brinjal if the cost of production is less than non-Bt brinjal and if the seeds were provided to them by BARI (when they are part of the project). The "Other" response category captures responses of around 6% of respondents who claim that they will adopt Bt-brinjal if BARI continues to provide them all input supplies for free.

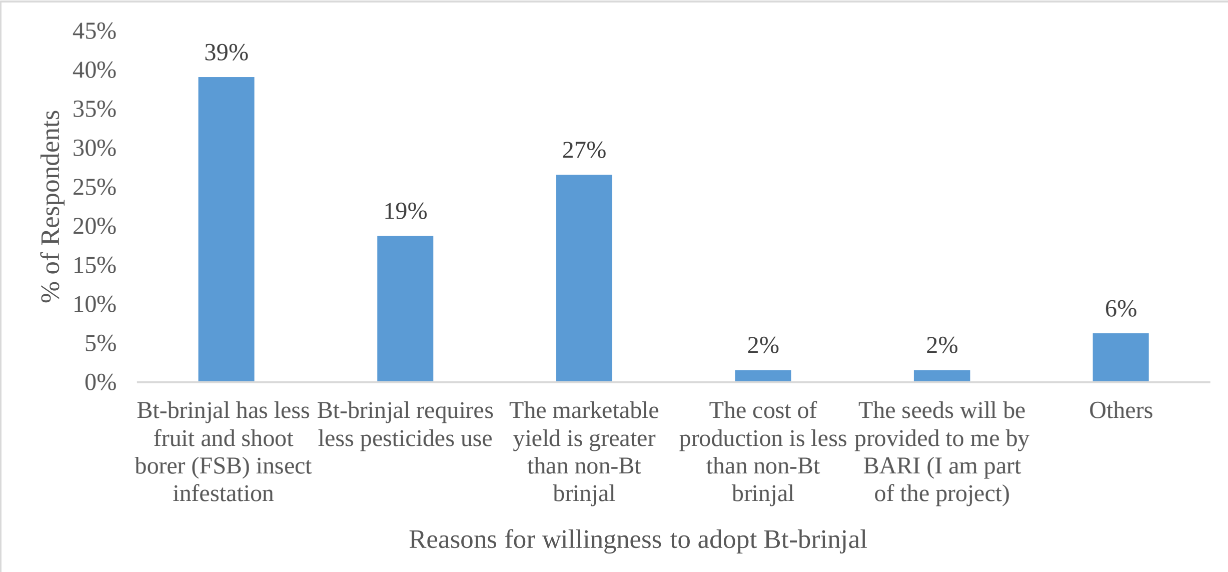


Figure 3.16: Reasons for willingness to adopt Bt-brinjal: Adopter survey

3.3.2 Bt-brinjal Non-adopter Survey

This study defines non-adopters as those who never grown Bt-brinjal. Like the adopter survey, this questionnaire also includes two screener questions to ensure that the survey was conducted with non-adopters. The final sample size of the non-adopters' survey is 46. Respondents were asked a question: "have you heard about Bt-brinjal before?" More than 50% of respondents replied that they heard about Bt-brinjal. Adopters and non-adopter surveys were conducted in the same places. Therefore, it is likely that non-adopters have heard about Bt-brinjal from neighbour farmers.

3.3.2.1 Socio-demographic Characteristics of the Sample: Non-adopter Survey

A set of socio-demographic questions were asked to the respondents (non-adopters). Like the adopter survey, more than 90% of the sample population were male (see Figure 3.17). The average age of the respondents is 43.91 years, similar to the adopters' average age at 42.26 years.

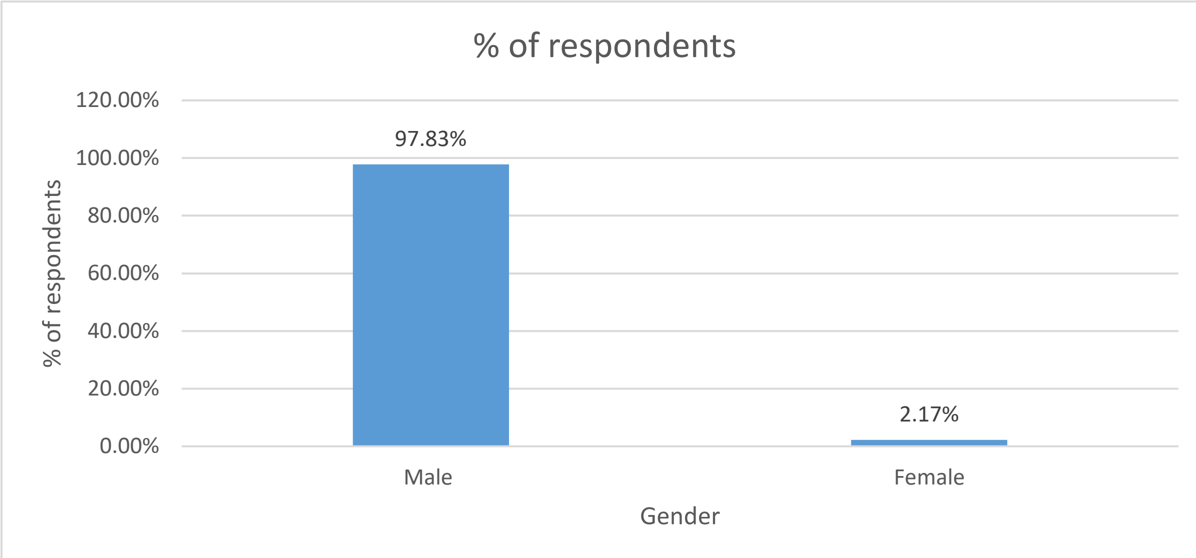


Figure 3.17: Gender of respondents (Non-adopter survey)

Figure 3.18 represents the percentage of respondents having various levels of education. It is found that 48% of respondents do not have education at all and 9% have college level of education (See Figure 3.18). Results on education levels demonstrated that adopters have better education compared to the non-adopters.

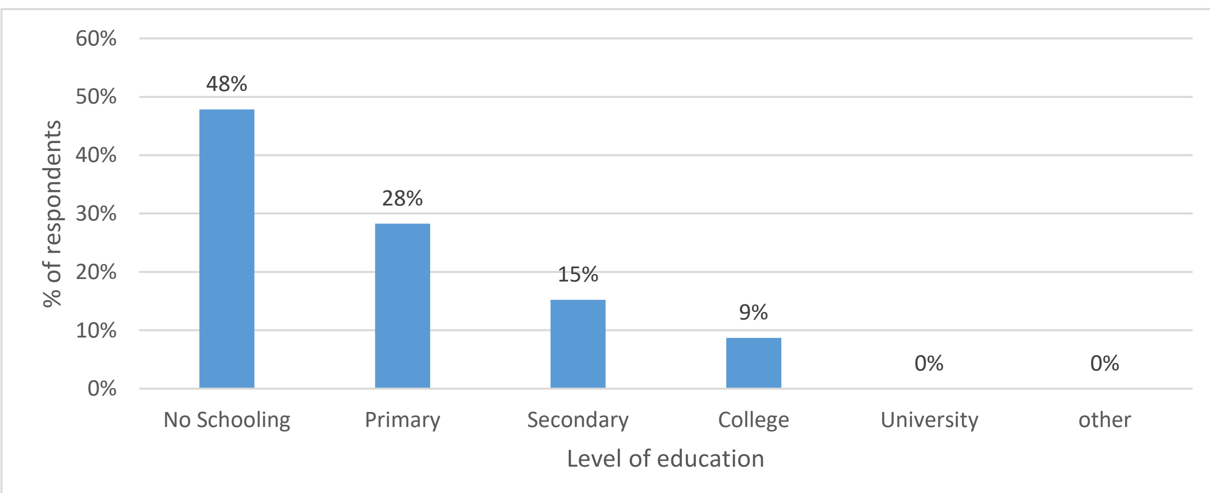


Figure 3.18: Level of education (Non-adopters)

3.3.2.2 General Farming and Marketing Practices of the Non-adopters

Participants were asked: "How often do you grow vegetables?" Similar to the adopter survey, a significant percentage of respondents also grow vegetables throughout the year. In Figure 3.19, around 57.45% grow vegetables all over the year and 42.55% grow vegetables mostly in the winter season.

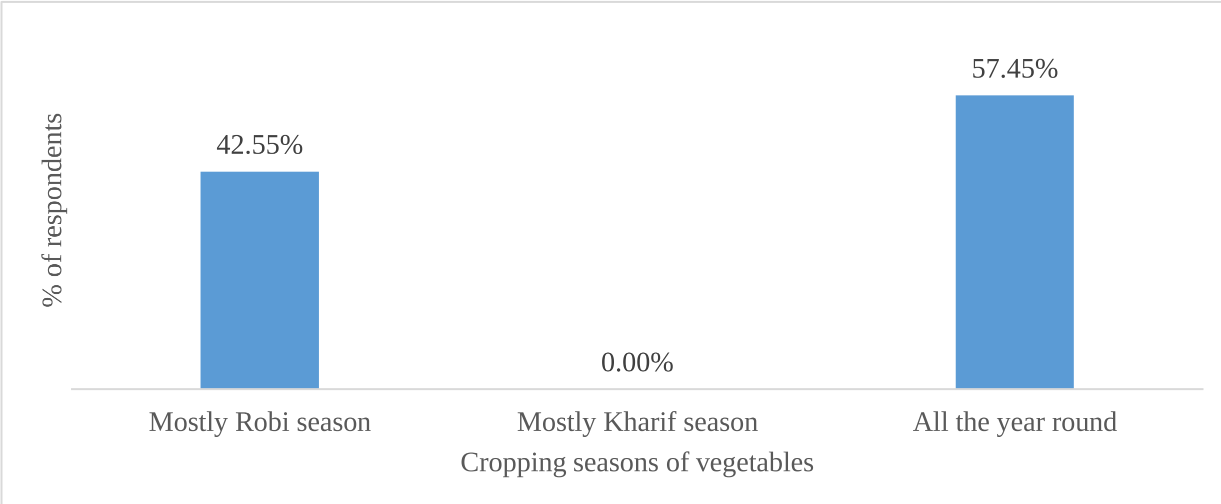


Figure 3.19: Cropping seasons (Non-adopter survey)

Like adopters, a higher percentage of respondents produce potato and brinjal as their main vegetables. Non-adopters also produce other vegetables, as with adopter farmers, as can be seen in Figure 3.20. The data revealed that 95.74% of respondents (non-adopters) grow other crops besides vegetables. Figure 3.21 represents the percentage of respondents producing other crops, where more than 90% grow rice, again a similar pattern as observed with the adopters.

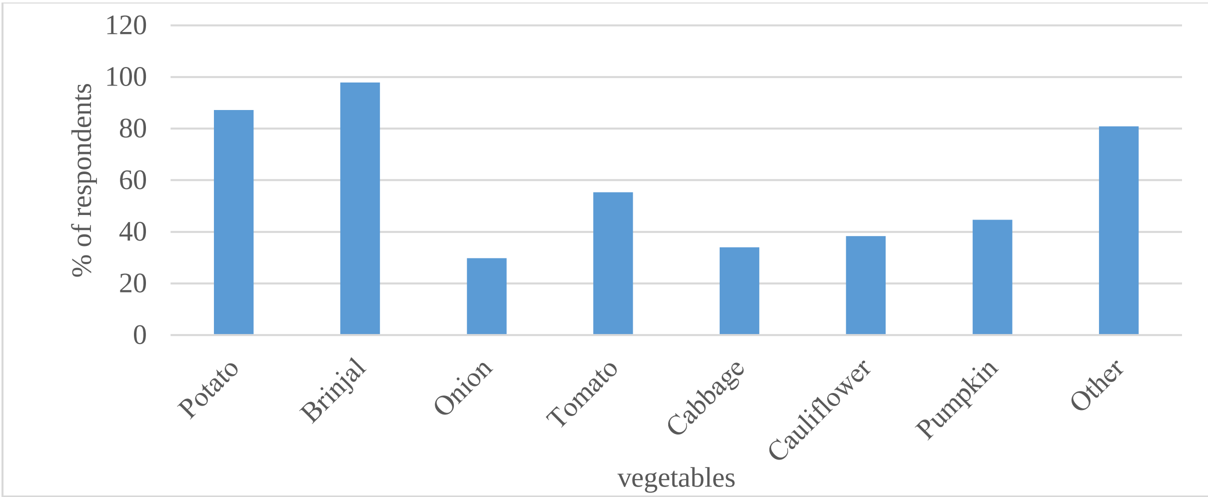


Figure 3.20: Major vegetables grown by non-adopters

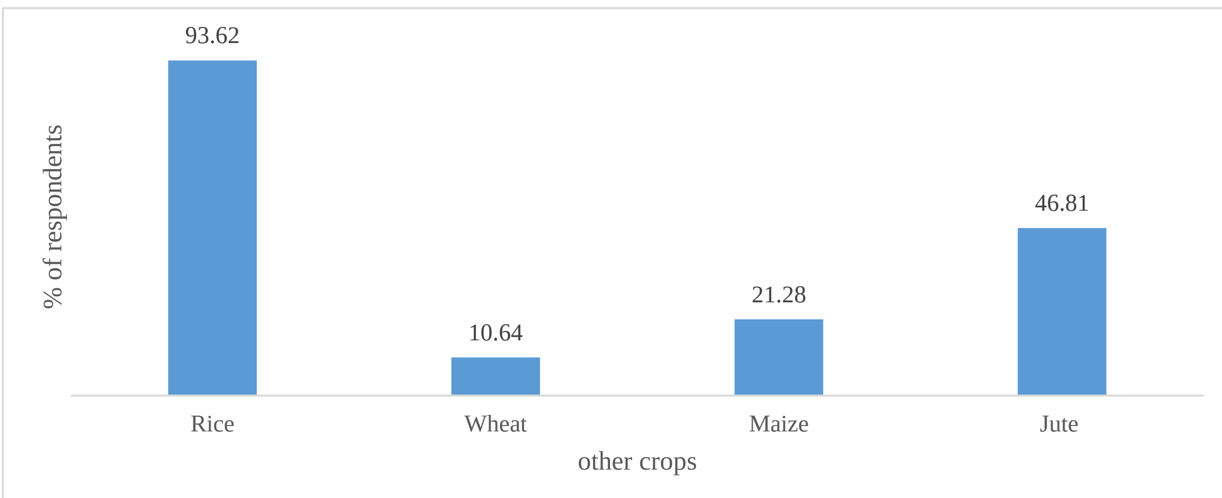


Figure 3.21: Other crops grown by non-adopters besides vegetable production

Non-adopters also use both varieties (hybrid and OPV) seeds for vegetable production. Figure 3.22 shows that 27.66% of non-adopters are solely dependent on the OPV and 25.53% are dependent on hybrid variety seeds. The use of OPV variety seeds among the non-adopters is higher compared to the adopters.

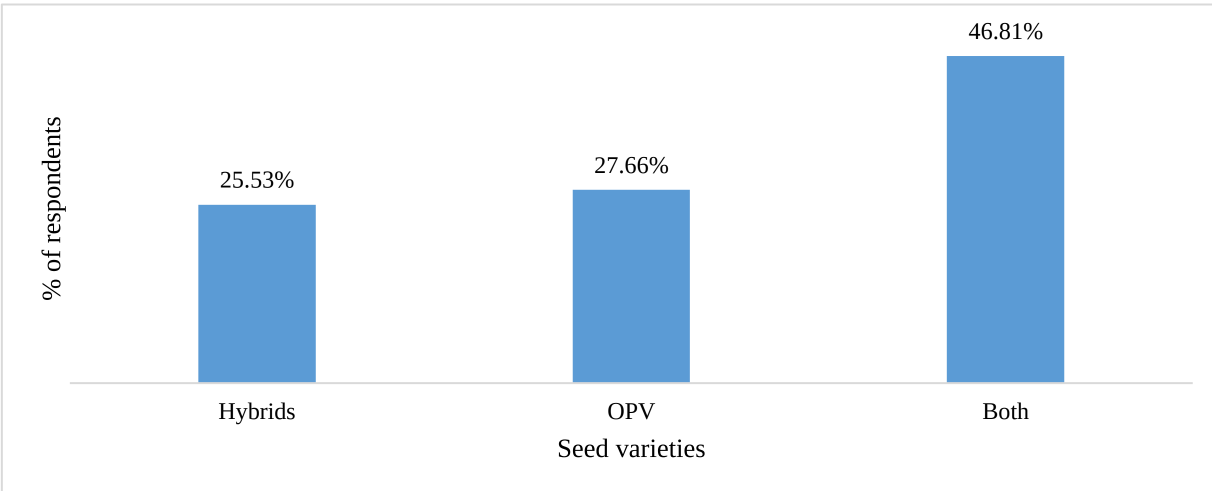


Figure 3.22: Use of hybrid and open-pollinated varieties: Non-adopter survey

Participants were asked about the source of vegetable seeds. Figure 3.23 shows that local dealers are one of the major sources for vegetable seeds. BARI plays a key role in providing Bt seeds to the adopter group. Thus, adopters maintain a regular contact with BARI offices, while non-adopters have less contact with BARI offices.

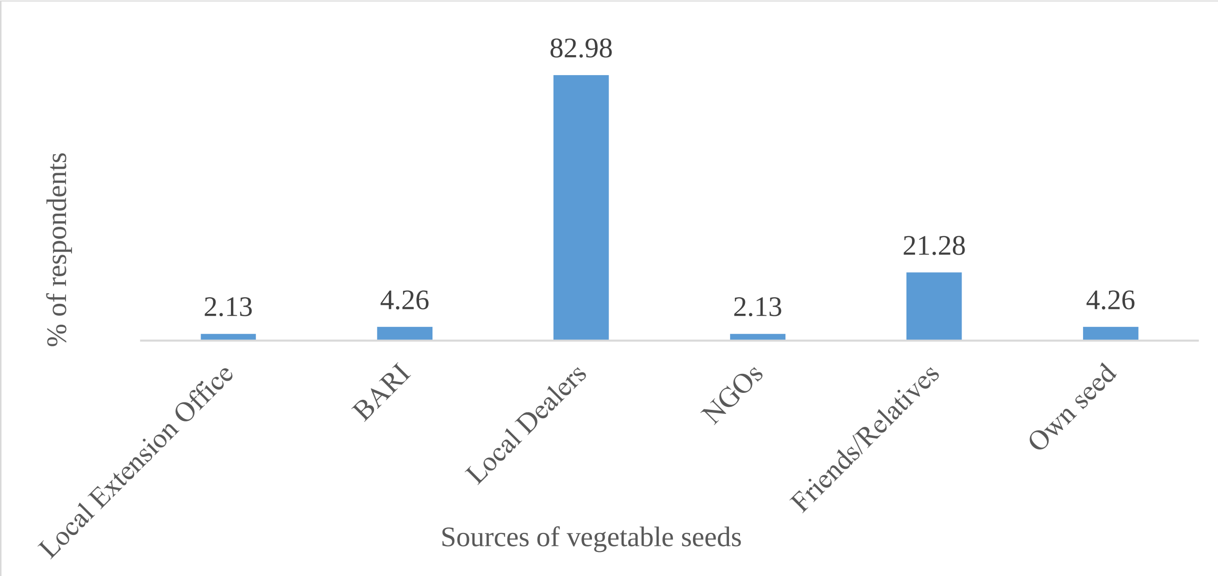


Figure 3.23: Sources of vegetable seeds: Non-adopter survey

The data shows that the average years of producing (non-Bt) brinjal is 12.64 years. Therefore, non-adopters have more experience of brinjal production than do the adopters. Like the adopter farmers, non-adopters also sell vegetables through various marketing channels, where 93.62 % of respondents sell through commission agents and 57.45% sell directly to the local market (see Figure 3.24).

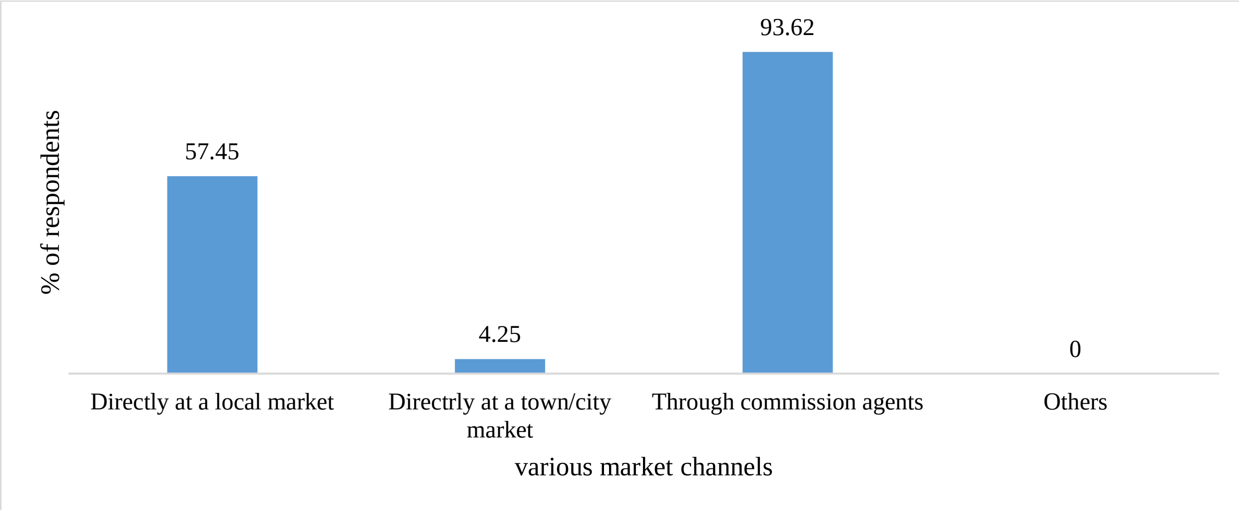


Figure 3.24: Marketing channels for selling vegetables: Non-adopter survey

3.3.2.3 Brinjal Production by the Non-adopters

Several questions were asked about respondents' experience of brinjal production in the previous year cropping year. During the previous cropping year, all of the respondents (100%) grew non-Bt brinjal on an average area of 0.12ha (see Table 3.6). All (100%) of respondents found FSB in their brinjal fields and 97.87% used pesticides to control this FSB insect. The average number of pesticide application is estimated as 30.34 times against the FSB insect over a whole season and the average number of pesticide application is 7.27 times against other pests. The minimum total number of pesticide spraying is 10 where the maximum number is 100. Respondents were also asked about the costs of brinjal seeds. Farmers in Bangladesh use various kinds of seeds. The price of seeds varies from one variety to another and as expected high quality seeds are more expensive than low-quality seeds.

Table 3.6: Non-Bt brinjal practices: Non-adopter survey

Questions	Units	Minimum	Maximum	Average/Total
The total land area that you used for brinjal production in the last season.	**Hectare (ha)**	0.012	1.21	0.12
Do you find the fruit and shoot borer (FSB) insect in your brinjal fields during the last season?	**% of respondents**	-	-	100%
Have you sprayed pesticides for FSB insect?	**% of respondents**	-	-	97.87%
How many times have you sprayed pesticides over a whole season for FSB insect only?	**No. of pesticide spraying**	10	100	30.34
Did you find any other pests in brinjal fields?	**% of respondents**	-	-	68.09%
How many times have you sprayed pesticides for the other pests over the season?	**No. of pesticide spraying**	0	60	7.27

3.3.2.4 Knowledge and Perceptions of Bt-brinjal (Non-adopter Survey)

To examine the level of knowledge about Bt-brinjal, a 5 point Likert scale was used, where 1 represents not at all knowledgeable and 5 represents very knowledgeable. A large portion of the non-adopter sample population lives near to the Bt-brinjal adopter farmers. Thus, more than half of the sample population have heard about Bt-brinjal, although 70% respondents claim not to be knowledgeable and only 26% claim to be slightly knowledgeable about Bt-brinjal (see Figure 3.25).

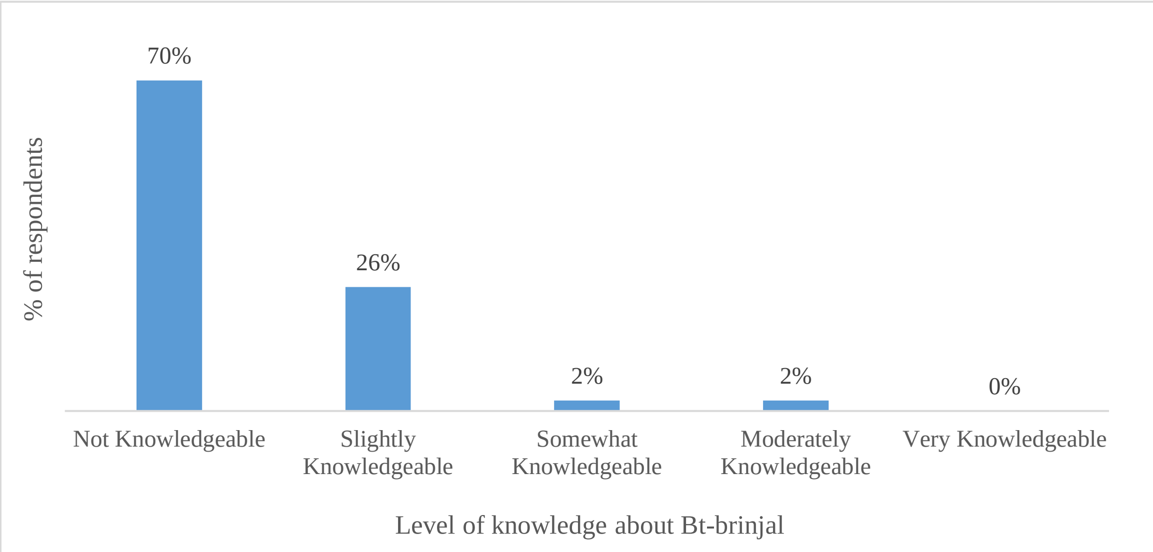


Figure 3.25: Level of knowledge about Bt-brinjal (Non-adopters)

Like the adopter survey, a question was also asked to the non-adopters: "Do you think that biosafety rules and regulations play a key role in the adoption process of Bt-brinjal?" Similar results are found to the adopters' survey as Table 3.7 shows that around 72% respondents agreed that biosafety rules and regulations play a significant role in the adoption process of Bt-brinjal and 28% respondents are not sure about the role of biosafety rules and regulations.

Table 3.7: Number and percentage of respondents (non-adopters) about the importance of biosafety rules and regulations

Questions	Responses	No. of respondents	% of respondents
Do you think that Biosafety rules and regulations play a significant role in the adoption process of Bt-brinjal?	Yes	33	72
	No	0	0.0
	Not sure	13	28

3.3.2.5 Willingness to Adopt Bt-brinjal (Non-adopter Survey)

A brief note about Bt-brinjal was first provided to the respondents before asking about the willingness to adopt Bt-brinjal. Like the Adopter Survey, Figure 3.26 shows that 91.30% of respondents (non-adopters) are willing to adopt Bt-brinjal if it is available to them. Similar to the adopters’ survey, non-adopters were asked to choose one most important reason from a list of 5 reasons. Figure 3.27 shows that 38.10% of respondents would like to adopt if Bt-brinjal requires fewer pesticide applications than the non-Bt brinjal, followed by if the marketable yield is more than the non-Bt brinjal (28%). Non-adopters were selected from the same villages where the adopter survey was conducted. Therefore, around 19% of the non-adopters claim that they would adopt Bt-brinjal because their neighbour produced Bt-brinjal recently and they are interested to produce Bt-brinjal in the next cropping season. Less FSB insect infestation was the most important reason for adopters’ willingness to adopt Bt-brinjal. There was no similar reason provided in the non-adopter survey.

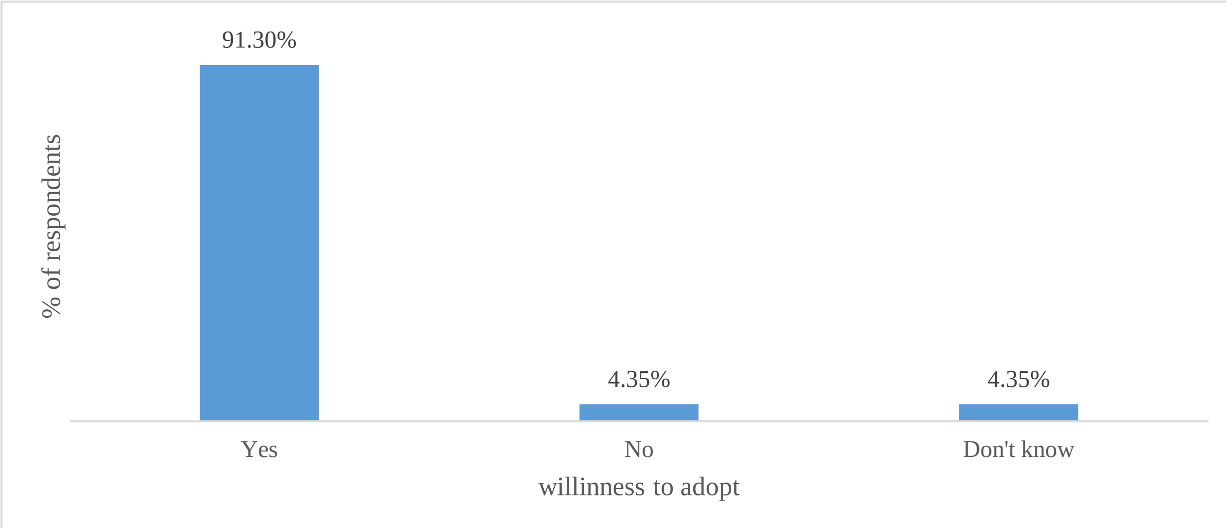


Figure 3.26: Non-adopters willingness to adopt Bt-brinjal

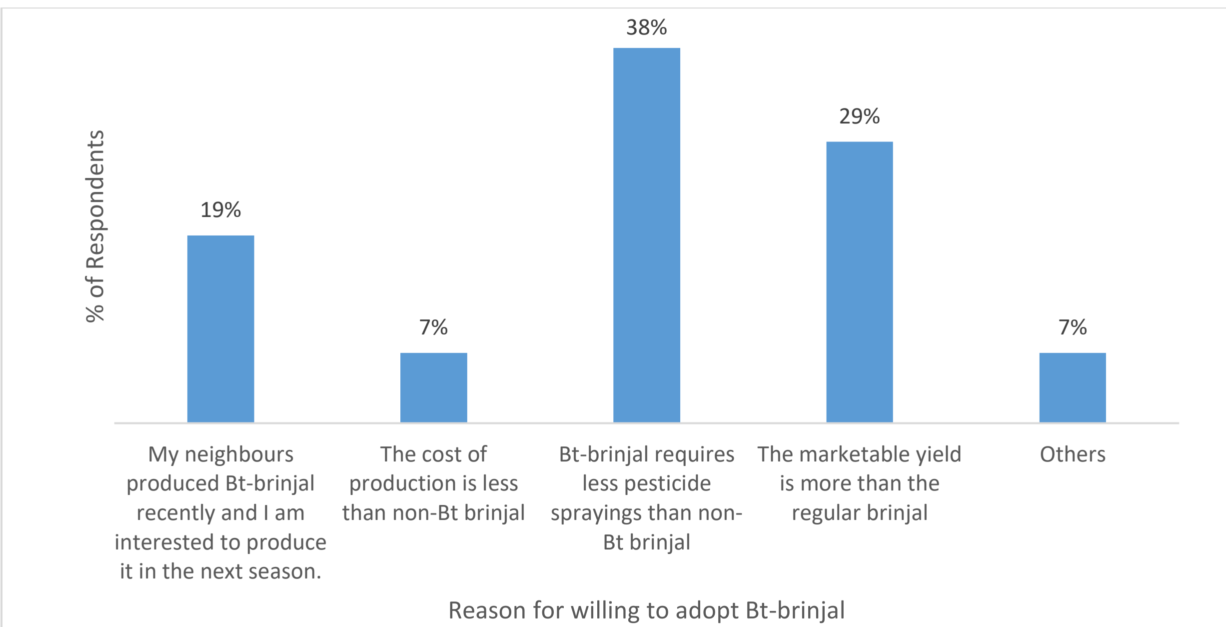


Figure 3.27: Reasons for willingness to adopt Bt-brinjal: Non-adopter survey

Seven statements were prepared to examine the perceptions of and attitudes towards Bt-brinjal among the non-adopters. An ordered scale of 1 to 5 was used, where 1 represents “strongly disagree” and 5 represents “strongly agree”. Figure 3.28 shows the perceptions of Bt-brinjal and shows a significant percentage of non-adopters strongly agree with all the statements, which are very similar to the results of the adopter survey. Adopters are more knowledgeable about Bt-brinjal than non-adopters.

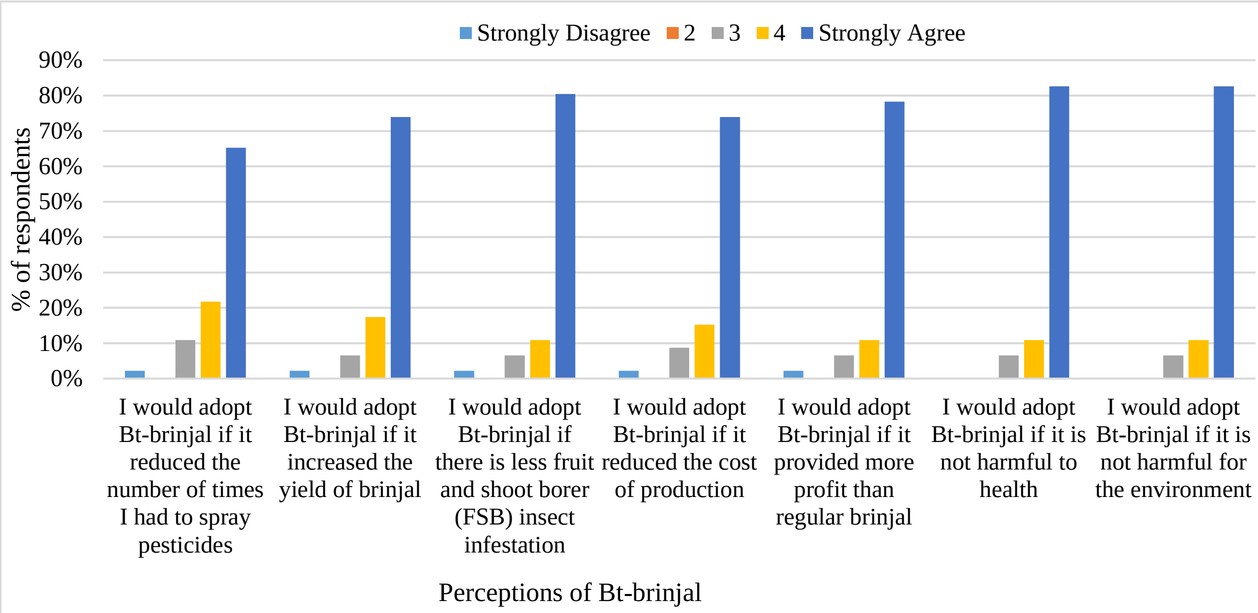


Figure 3.28: Perceptions of Bt-brinjal (Non-adopter survey)

3.3.3 Consumer survey

As mentioned above, around 30 consumers were interviewed for the consumer survey. Two-screener questions were used to ensure that consumers are the primary food shopper and normally purchase brinjal for the household.

3.3.3.1 Socio-demographic Characteristics of the sample: Consumer Survey

Figure 3.29 shows that more than 80% of respondents were male. Typically, it is the male member of a household who is responsible for the food shopping in Bangladesh. The data were collected from various categories of people including residents of villages and cities. Most of the respondents were interviewed from village areas. Village women in Bangladesh usually do not participate to go local market to do their daily groceries. Therefore, this study finds more than 80% of the respondents are male who usually go for daily groceries. The average age is estimated as 38.17 years and the average family size is 4 (see Table 3.8).

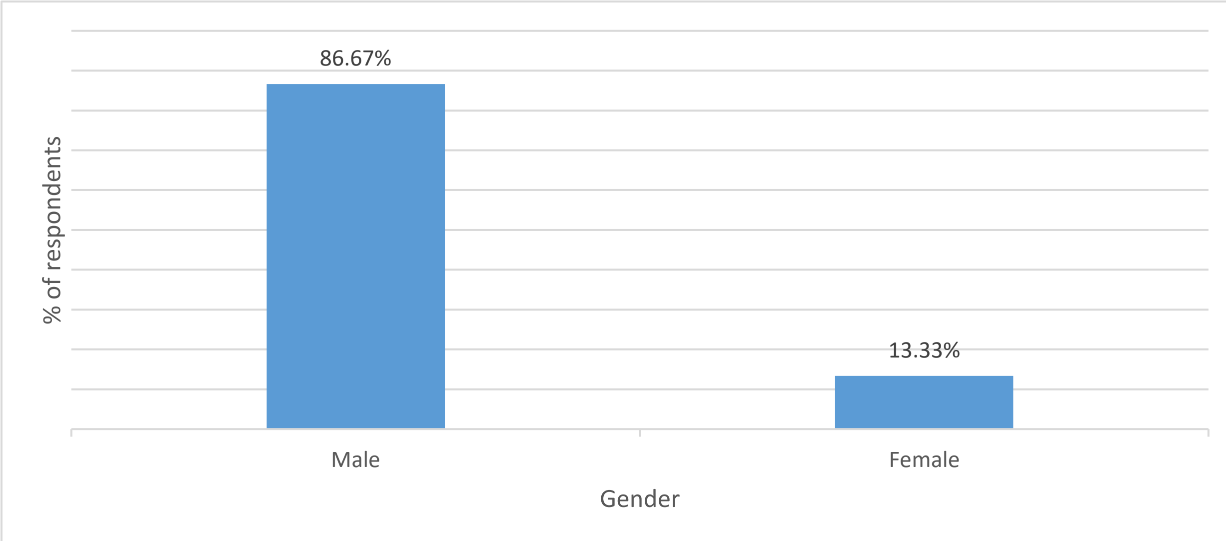


Figure 3.29: Gender (Consumer survey)

People interviewed for the consumer survey fell into different income categories. Around 30% of respondents have farm income, while others have non-farm income and 10% of respondents were students. Thus, annual income varies significantly from one consumer to another. The average annual income is estimated as BDT 228,500 where the minimum annual income was BDT 0 and maximum annual income is BDT 700,000 (see Table 3.8).

Table 3.8: Socio-demographic (Consumer survey)

	Units	**Minimum**	**Maximum**	**Average/Total**
Gender	Male (% of respondents)	-	-	86.67
	Female (% of respondents)	-	-	13.33
Age	Years	23	62	38.17
Family size	No of household members	1	9	4
Annual income	BDT	0	700,000	228,500

Consumers also were asked about their level of education. Figure 3.30 shows that 43.33% of respondents have university level education where only 13.33% have no schooling. According to the World Bank (2015), the average years of schooling is 6.5, which means a secondary level of education (high school). Figure 3.30 shows that only 16.67% of respondent have a secondary level education.

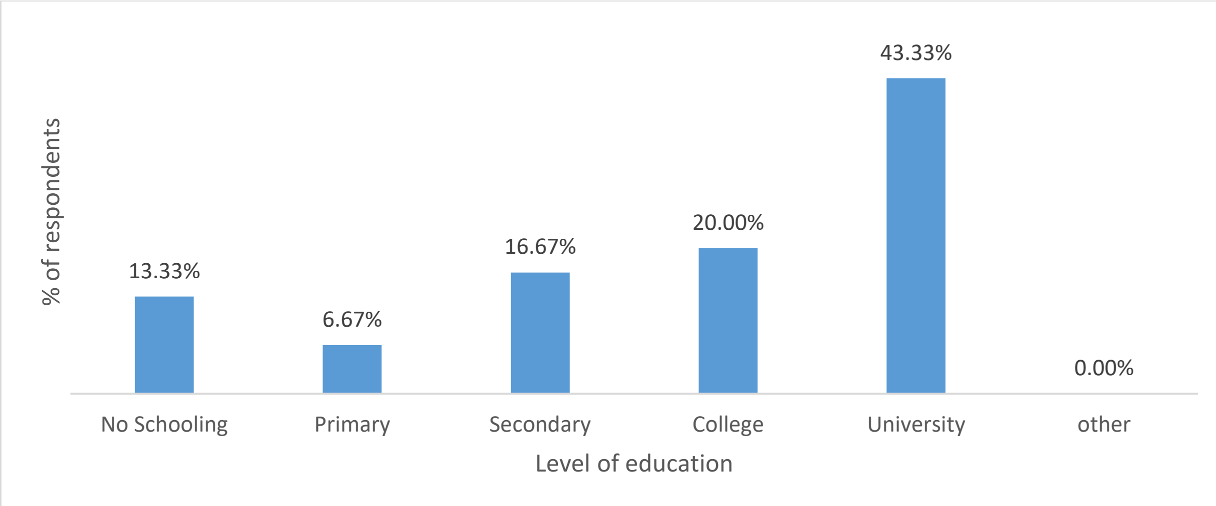


Figure 3.30: Consumers level of education

3.3.3.2 Knowledge of Bt-brinjal (Consumer Survey)

Respondents were asked “Have you heard about Bt-brinjal before?” Around 47% answered that they have heard about Bt-brinjal. The following question was asked: “From whom have you heard about Bt-brinjal?” Figure 3.31 shows that approximately 38%, 29%, 14% and 7% of respondents heard about Bt-brinjal from friend/relatives, local farmers, media and the local market, respectively. The consumer survey was conducted in those areas where Bt-brinjal is available nearby. Thus, they get preliminary information about Bt-brinjal from their friends/relatives and the local markets. A question was also asked about their knowledge of Bt-brinjal. Respondents claim that they have heard about the name Bt-brinjal but are not particularly knowledgeable about it. Figure 3.32 shows that more than 70% of respondents do not have any knowledge about Bt-brinjal, and only 7% claim to be moderately knowledgeable.

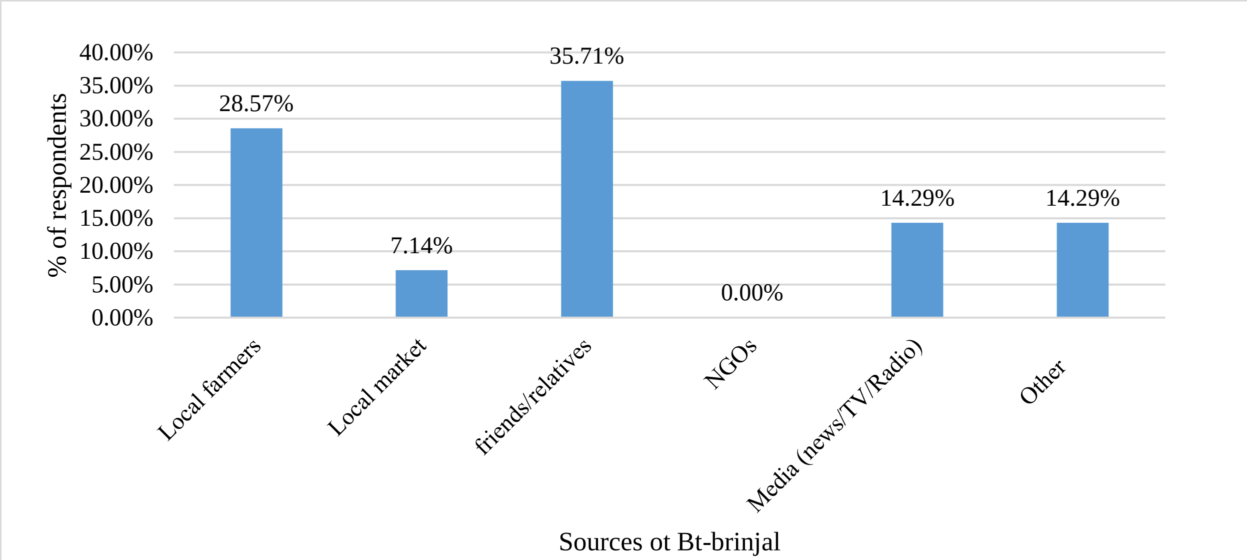


Figure 3.31: Information sources of Bt-brinjal (Consumer survey)

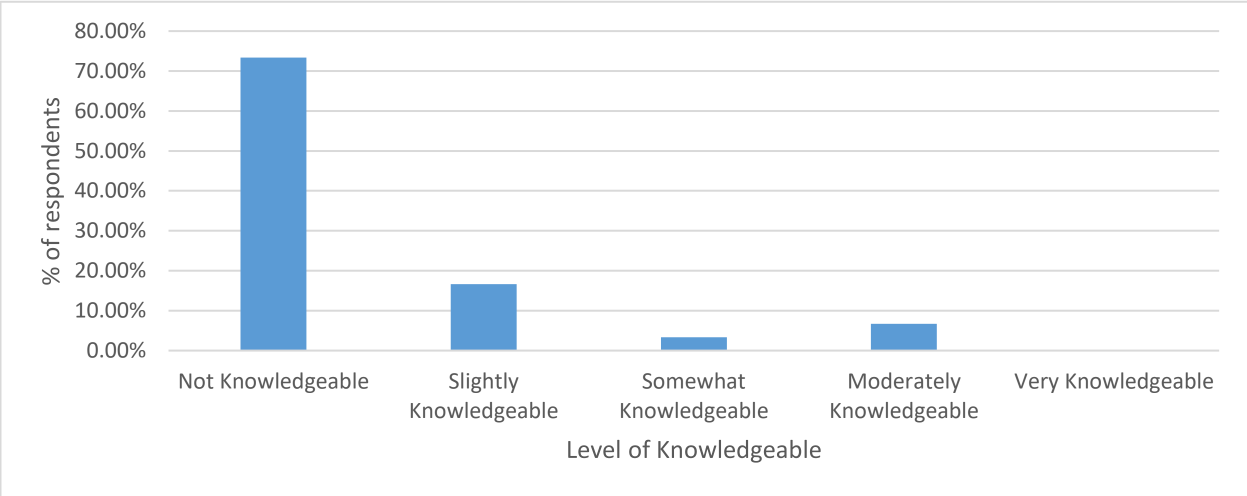


Figure 3.32: Level of knowledge about Bt-brinjal: Consumer Survey

A question regarding the importance of biosafety rules and regulation was also asked, and almost 100% of respondents agreed that biosafety rules and regulations were important in the development of biotechnology.

3.3.3.3 Willingness to Buy: Consumer Survey

A brief note was also provided about Bt-brinjal to the respondents before approaching the willingness to buy questions[6]. Figure 3.33 shows that more than 90% of respondents are willing to buy Bt-brinjal. Consumers were also asked to indicate the reason for their willingness to buy from a list of four options. Figure 3.34 shows that 72% of respondents are willing to buy Bt-brinjal if Bt-brinjal has less pesticide residue than non-Bt brinjal. The second most important reason for consumers' willingness to buy is that Bt-brinjal has the same nutritional value as non-Bt brinjal (17%), while only 3% indicated that they preferred the taste of Bt-brinjal rather than non-Bt brinjal (captured in the 'Other' response category).

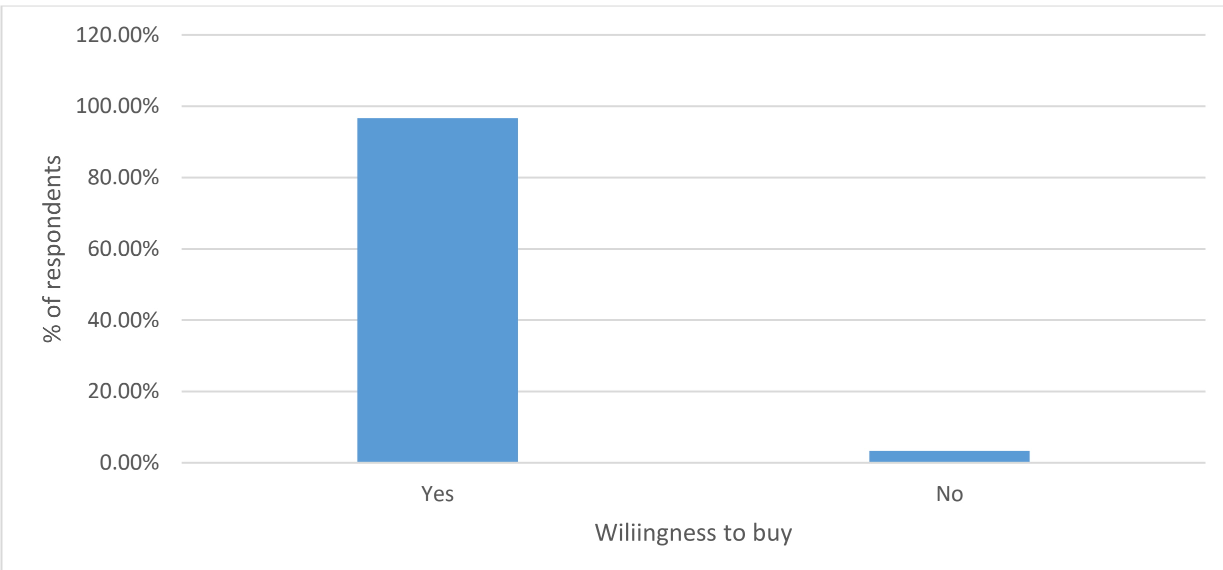


Figure 3.33: Consumers' willingness to buy Bt-brinjal

[6] Bt-brinjal in Bangladesh (Consumer Survey)
a. Bt-brinjal is a new variety of brinjal which has been developed to give resistance against the fruit and shoot borer (FSB) insect. The fruit and shoot borer (FSB) insect is the most voracious insect that affects brinjal.
b. Bt-technology is a technology transfer project and developed by Mahyco (an Indian Company), with the collaboration of Cornell University and Funded by USAID.
c. Bangladesh Agricultural Research Institute (BARI) developed four varieties of Bt-brinjal and it was approved for limited cultivation in Bangladesh in 2013.
d. Now more than 200 farmers in Bangladesh are producing Bt-brinjal.
e. It reduces the use of pesticide in brinjal fields. Some estimates suggest it can reduce pesticides spraying by up to three-quarters (75%) and as a result there is less pesticide residue in Bt-brinjal fruits.
f. Bt-brinjal has less insect damage than the non-Bt brinjal.
g. Bt-brinjal contains the same nutritional value as the non-Bt brinjal.

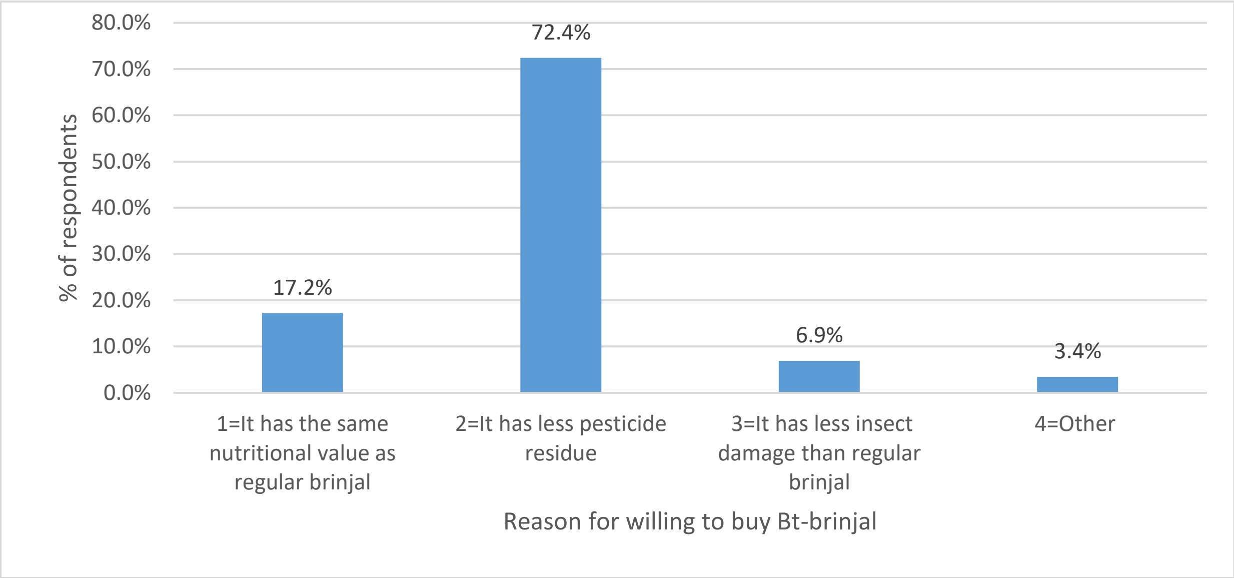


Figure 3.34: Reasons for willingness to buy Bt-brinjal (Consumer Survey)

Four statements were also provided to examine consumer's perceptions of Bt-brinjal. An ordered scale was also used as with the other surveys, where 1 to 5 represents the scale from strongly disagree to strongly agree. Figure 3.35 reports the perceptions of Bt-brinjal and it shows that more than 60% respondents strongly agreed with the statements 'I would buy Bt-brinjal if it contained less pesticide residue than regular brinjal' and 'I would buy Bt-brinjal if it was not harmful to health'.

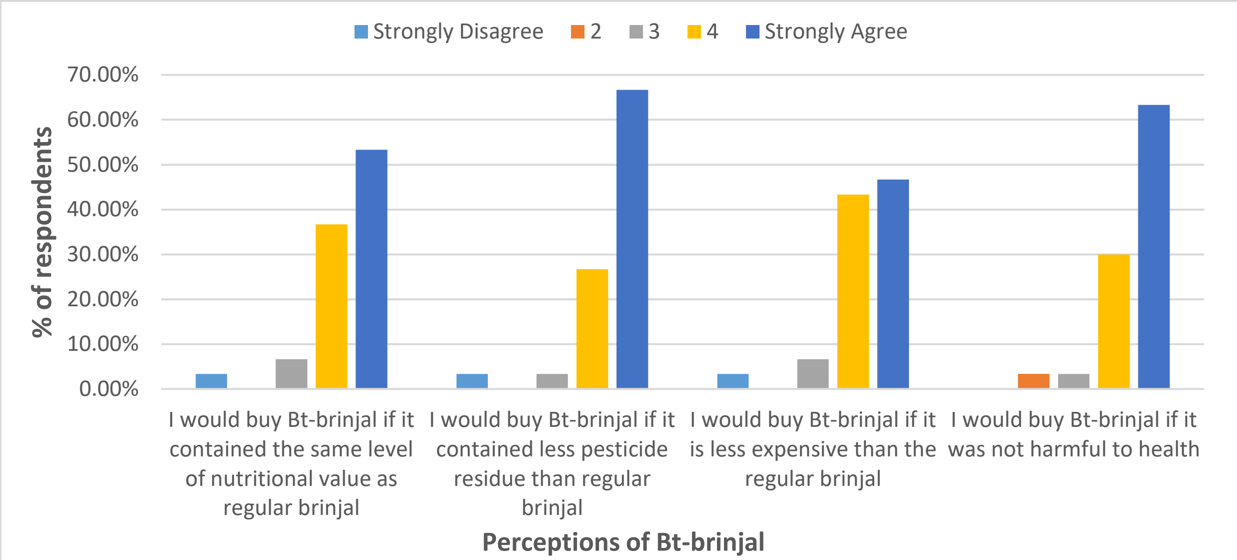


Figure 3.35: Perceptions of Bt-brinjal (consumer survey)

3.4 Conclusions

The first part of this chapter described the research design, including the development of survey questionnaires, selection of the study areas and data collection. The second part described the descriptive analysis of the sample population of each survey. Both adopters and non-adopters claim themselves to be non-Bt brinjal producing farmers. Therefore, the characteristics of vegetable farming and marketing practices are quite similar in both cases. Regarding the knowledge about Bt-brinjal, adopters are more knowledgeable than the non-adopters. BARI plays a technical transfer and educational role in informing adopters about Bt-brinjal, whereas non-adopters do not have much access to information about this new crop, which is similar to the situation faced by consumers.

Adopters and non-adopters show a strong willingness to adopt Bt-brinjal. The fruit and shoot borer (FSB) insect infestation is the most dangerous problem in the brinjal production period. Adopters are willing to adopt Bt-brinjal in the future because Bt-brinjal has less FSB insect infestation, while non-adopters are willing to adopt Bt-brinjal because of less pesticide application in Bt-brinjal fields (reasons that are clearly related). Consumers also showed a high acceptance rate regarding the willingness to buy Bt-brinjal, where less pesticide residue is the most important reason encouraging their willingness to buy.

Adopters' and non-adopters' willingness to adopt Bt-brinjal are examined in the next chapter through an econometric model using Stata 15. The descriptive analysis presented in this chapter helps to identify the dependent and independent variables for the econometric model.

Chapter 4 Estimation Methods and Results

4.1 Introduction

This chapter outlines the estimation methods used in the analysis of the adopters and non-adopter surveys. This study examines social license for the adoption of Bt-brinjal in Bangladesh. However, there is no exact measurement of social license for the adoption of a new technology. Typically, technology adoption studies employ a dichotomous choice method to evaluate the adoption decision or willingness to adopt, however, given the very high stated willingness to adopt among current adopters and non-adopters, this analysis was not feasible. A variation on a willingness to adopt measure is used instead, in the form of a multinomial logit model which identifies the major reasons behind willingness to adopt for both the adopters as well as the non-adopters.

This chapter is organized as followed: a brief discussion of the estimation methods is provided in section 4.2. A discussion of the multinomial logit model applied to the adopter survey data is provided in section 4.3. Section 4.4 discusses the multinomial logit model used in the non-adopter survey analysis. Section 4.5 discusses the insights from the consumer survey and other stakeholder interviews. Conclusions to the chapter are provided in section 4.6.

4.2 Estimation Methods

Social license measures stakeholders' level of acceptance and approval of new technology adoption. Social license for adopting a new GM technology depends mostly on stakeholders' willingness to adopt the technology and their technology adoption decisions. Therefore, willingness to accept may influence the adoption of that technology as well as its level of social license. The greater the willingness to adopt or accept a new technology among several stakeholders the more likely to lead it is the establishment of social license for that technology.

In the case of brinjal farmers in Bangladesh, it is challenging to measure their willingness to adopt Bt-brinjal. Bt-technology is still in the phase of commercialization because the Bt-seeds are not available commercially on the market. Instead, the Bangladesh Agricultural Research Institute (BARI) provides all necessary input supports to the Bt-brinjal adopters. This means that the adopters maintain a direct connection with the BARI officials. This may bias simple measures of willingness to adopt at this point in time, possibly explaining the very high proportion of respondents who indicated a positive willingness to adopt. BARI also confirmed that the DAE has also been working with local farmers since 2015. The data were collected only from those adopter farmers who were identified by BARI. Adopter farmers working with DAE were not included in the study because of time limitations.

In addition to Bangladesh, a few other countries, are also trying to approve Bt-brinjal, for example, India and the Philippines. A number of studies have been done on an ex-ante basis in those countries. Kolady and Lesser (2006) conducted an ex-ante study in India to examine the factors that would influence farmers' decisions to adopt Bt-brinjal while hybrid brinjal is available in the market. The study used a bivariate probit model to analyze whether hybrid brinjal growers would behave differently if Bt-brinjal were available in the market. They used a random utility framework to model farmers' willingness to adopt a new technology. According to utility measurement theory, an adopter is more willing to adopt a technology when the cost of new technology is less than the old technology and provides benefits at least as great as the old technology (Kolady and Lesser, 2006).

Like Kolady and Lesser (2006), this study also investigates willingness to adopt Bt-brinjal in Bangladesh but is an ex post analysis where it is possible to identify the farmers currently growing (adopters) and not growing (non-adopters) Bt-brinjal. A binary probit model was first considered as a method to examine willingness to adopt/accept Bt-brinjal in Bangladesh. A binary probit model is not well suited to the data, however, because of the high level of acceptance and willingness to adopt Bt-brinjal among both the surveyed adopters and non-adopters. The descriptive analysis shows that more than 90% of the adopters have the positive willing to adopt Bt-brinjal in the near future, which is similar to the non-adopter survey data (see chapter 3). Thus, the probability of willingness to accept (Y) responses, which is $Y_i=1$ is much higher than the probability of $Y_i=0$ in the probit model for both surveys. Instead, an alternative model, a multinomial logit model (MNL) was used for the analysis of the adopter and non-adopter survey data which focuses on the *reasons* for willingness to adopt.

Respondents were asked to specify a primary reason among several reasons for their willingness to adopt Bt-brinjal. A number of reasons were provided in the survey as discussed in the descriptive analysis in chapter 3. In the adopters and non-adopter survey, 6 reasons and 5 reasons were provided to the respondents respectively in the survey.[7] Therefore, a categorical dependent variable is used in the analysis. The dependent variable is defined as: what is the most important reason that motivates the adopters/non-adopters willingness to grow Bt-brinjal.

Logistic regression analysis is used to analyze a binary dependent variable (such as adopt/non-adopt), while, a multinomial logit model (MNL) is used to analyze a categorical dependent variable, as discussed for example by Wang et al. (2017) and Guris et al. (2007). A binary logit model provides only one equation for the outcome variable while in case of the multinomial logit model, there are K-1 equations. For example, if the dependent variable has K categories of responses then a multinomial logit model provides K-1 equations.

A multinomial logit model (MNL) simultaneously uses all of the response categories by specifying the odds of an outcome in one category instead of another category (Agresti, 2007). A MNL model can be used for nominal or ordinal response categories. A nominal response means where categories do not follow a scale of order (unordered categories) and an ordinal response means when response categories follow a scale of order, for example, a scale of 1 to 5, strongly disagree to strongly agree.

This study uses nominal response categories for the dependent variable. A multinomial logit model for nominal response categories uses a baseline category to compare each response category with the baseline category. Assume, J is the number of response categories in the dependent variable Y and P_1, P_2 …… P_j are the response probabilities. The probabilities are calculated to estimate the odds ratio of a j response among J alternatives. The probability of a j response among J alternatives in the dependent variable is $P(Y = j \mid X)$, where X_i is the case specific repressors to explain every alternative in the dependent variable. Following Guris et al. (2007), a multinomial logit model is obtained as:

$$P(Y_i = j \mid X_i) = \frac{e^{\alpha j + \beta j X i}}{\sum_{j=1}^{M} e^{\alpha j + \beta j X i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1$$

where, α_j and β_j are the intercepts and coefficients for X_i repressors. Thus, there is one set of coefficients for each alternative. The probabilities are positive in value and the total of probabilities

[7] See Figure 3.16 and Figure 3.27 in chapter 3. These figures portray the major reasons for willingness to adopt Bt-brinjal.

P $(Y_i=j)$ is equal to one. Therefore, the model in equation 1 has J numbers of equations of which only (J-1) can be estimated and the coefficients for each category can be interpreted with respect to the base outcome category.

4.2.1 Interpretation of Multinomial Logit Model and Marginal Effects

According to Wulff (2015), there are two issues that complicate the interpretation of the coefficients in a multinomial logit model. The base outcome category, which is used in the model as the dependent variable's response category, represents contrasts among other categories and makes it difficult to see the implications for each category purely from the coefficients (Wulff, 2015). Furthermore, according to Long (1997) and Long and Freese, (2006), the coefficients in a MNL model do not necessarily mean that an increase in the independent variable corresponds to an increase in the probability of choosing a particular outcome category. The relationship between independent variables and base outcome category in a MNL model is not linear and may even change the sign across the distribution of a single predictor (Wulff, 2015). Thus, researchers use predicted probabilities and marginal effects to interpret the direction, magnitude and significance in a MNL model. While predicted probabilities provide the information about the direction and magnitude of the relationship, marginal effects are a very powerful interpretative device to explain the results from a MNL model. According to Wulff (2015), the marginal effects can be defined as the slope of the predicted function at a given value of the explanatory variable and thus explain the change in predicted probabilities due to a change in a particular predictor. This study calculates marginal effects from the regression parameter estimates to explain the results from the multinomial logit model.

4.2.1.1 Marginal Effects

Both discrete and continuous choice models use marginal effects to interpret the variables. Marginal effects for continuous variables measure the instantaneous rate of change, meaning that it provides a good approximation to the amount of change in the dependent variable which will be estimated by a one unit change in the explanatory variables. Marginal effects for categorical variables measure the discrete change on the predicted probabilities as the binary independent variable changes from 0 to 1. Marginal effects are calculated differenctly for both categorical and continuous variables. Wulff (2015) uses a simple equation for estimating the marginal effects for a multinomial logit model. Thus, following Wulff (2015), the equation for marginal effects is:

$$\mathrm{ME}_{ij} = \frac{\partial p_{ij}}{\partial x_{ik}} = \frac{\partial \Pr(y = j|x_i)}{\partial x_{ik}} = p_{ij}(\beta_{kj} - \bar{\beta}_i) \; \ldots\ldots\ldots\ldots\ldots \; 2$$

Where, $\bar{\beta}_i$ is the probability weighted average of the coefficients for different choice combinations, $\bar{\beta}_{kj}$. Marginal effects from a MNL model are always nonlinear and vary among values of all the variables in the model.

4.3 Multinomial Logit Model: Adopter Survey

4.3.1 Description of the Dependent and Explanatory Variables (Adopter Survey)

This study uses a multinomial logit model (MNL) to analyze response categories for the dependent variable. The dependent variable is defined as: what is the most important reason that drives willingness to adopt Bt-brinjal. Table 4.1 describes the dependent and its' four response categories, indicating the base outcome category. Table 4.2 describes the explanatory variables included in the model. The dependent variable (Y) has four response categories, including: Reason 1: Bt-brinjal has less fruit and shoot borer (FSB) insect infestations; Reason 2: Bt-brinjal requires fewer number of pesticide applications than non-Bt brinjal (base outcome); Reason 3: Marketable yield is more than non-Bt brinjal production and Reason 4: Other reasons. Reason 2 is used as the base outcome category for the dependent variable because it exhibits the highest frequency among the reasons. Outcome response categories are correlated with each other and may overlap to some extent, nevertheless, the objective was to identify specific reasons for willingness to adopt Bt-brinjal.

Table 4.1: Description of the dependent variable (Adopter survey)

Dependent Variable	**Code**	**Description of Response Categories**
What is the most important reason that drives adopter's willingness to adopt Bt-brinjal	1	**Reason 1:** Bt-brinjal has less Fruit and Shoot Borer (FSB) insect infestations.
	2	**Reason 2:** Bt-brinjal requires a fewer number of pesticide applications than non-Bt brinjal (base outcome)
	3	**Reason 3:** Marketable yield is more than non-Bt brinjal
	4	**Reason 4:** Others

Turning to the explanatory variables explained in Table 4.2, the variable 'District' (DISTRICT_bt) is included in the adopter survey model as a binary variable, with those districts where farmers have produced Bt-brinjal more than once coded as 1 and 0 otherwise. Kolady and Lesser (2006) stated that contextual characteristics such as the 'District' variable may capture agro-climatic differences, infrastructure variations and regional preferences and they may influence the farmers' adoption decision. Brinjal is an important crop in Bangladesh and there are 103 varieties of brinjal in Bangladesh. Different varieties of brinjal are produced in different regions of Bangladesh. Therefore, the district variable captures regional preferences and patterns in the adoption of Bt-brinjal. 'Winter season' (ROBI_bt) is also used as a dummy variable, where 1 indicates the respondent's main vegetable growing season is winter and 0 otherwise. The winter season is the major vegetable growing season in Bangladesh. There are fewer insect infestations in the vegetable crops in the winter season than in the other seasons. 'Experience of Bt and non-Bt' is also used as a dummy variable (BRNJLPRDCTN_bt), where 1 means adopters have experience of producing both Bt-brinjal and non-Bt brinjal at the same time and 0 otherwise. Experience in producing both Bt-brinjal and non-Bt brinjal may help the adopters to understand the difference between producing Bt-brinjal and regular (non-Bt brinjal) and the benefits of producing a new crop (Bt-brinjal). Thus, it is hypothesized that the experience of producing both Bt-brinjal and non-Bt brinjal may influence the adoption of Bt-brinjal.

A variable capturing the marketing channel used by the farmers was defined as 'Vegetables sold in the local market' which also is used as a dummy variable (MRKTCHNNL_bt), coded as 1 if farmers sell vegetables directly to the local market and 0 otherwise. In Bangladesh, a substantial portion of farmers are marginal farmers and they market their vegetables directly to the local market. Vegetables are perishable in nature and there is a lack of storage facilities in Bangladesh. Thus, the small farmers are prefer to sell their vegetable in the local market where they have direct contact with buyers. 'Seed variety' is defined as VARIETY_bt (dummy), where 1 means respondents use hybrid seeds for vegetable production and 0 otherwise. Bangladeshi farmers are now using both varieties (hybrid and open-pollinated varieties) for vegetable production. Hybrid seeds provide more benefits than conventional seed varieties. As marginal farmers, they do not have a large amount of farming land. Thus, farmers are now using hybrid seeds more than the conventional seeds. Therefore, the farmers who like to use hybrid varieties more than open-pollinated varieties may approach technology adoption decisions differently.

A number of continuous variables are also included in the model. The total number of pesticide applications in non-Bt brinjal fields to control FSB insects (PestnonBtFSB_bt) during the last cropping season and the total number of pesticide applications in the non-Bt brinjal fields to control other insects (PestnonBtOther_bt) during the last cropping season are used as continuous variables. Pesticide applications to control insect infestation in vegetable fields also may influence the decision to adopt Bt-brinjal. Bt-brinjal is resistant to the FSB insect but some other insects may attack the Bt-brinjal plants. Therefore, another variable is used in the model, which is defined as the total number of pesticide applications in the Bt-brinjal fields to control other insects (PestBtOther_bt) during the last cropping season.

Table 4.2: Description of the explanatory variables (Adopter survey)

Independent Variables	**Code**	**Description**
District variable	DISTRICT_bt	Binary variable, 1= Those districts, where farmers have produced Bt-brinjal more than once and 0=Otherwise
Winter season	ROBI_bt	Dummy, 1 if main vegetable growing season is winter season (Robi Season) and 0 otherwise
Experience of brinjal production (both Bt and non-Bt)	BRNJLPRDCTN_bt	Dummy, 1 if farmers produce both Bt-brinjal and non-Bt brinjal at the same time and 0 otherwise
Vegetables sell in the local market	MRKTCHNNL_bt	Dummy, 1 if adopters sell vegetables directly to the local market and 0 otherwise
Seed variety	VARIETY_bt	Dummy, 1 if farmers use hybrid seeds and 0 otherwise
Number of pesticide applications in non-Bt field for FSB insect	PestnonBtFSB_bt	Total number of pesticide applications to control FSB insect in non-Bt brinjal field during the last cropping season
Number of pesticide applications in non-Bt field for other insects	PestnonBtOther_bt	Total number of pesticide applications to control other insects in non-Bt brinjal field during the last cropping season

Number of pesticide applications in Bt-brinjal field for other insects	PestBtOther_bt	Total number of pesticide applications to control other insects in Bt-brinjal field during the last cropping season
The yield of non-Bt brinjal	YieldnonBt_bt	Marketable yield of non-Bt brinjal during the last cropping season (Kg/Decimal)
The yield of Bt-brinjal	YieldBt_bt	Marketable yield of Bt-brinjal during the last cropping season (Kg/Decimal)
Yield difference	Yielddifference_bt	Yield difference from yield of Bt-brinjal to yield of non-Bt brinjal
Knowledge of Bt-brinjal	Knowledge_bt	Categorical variable (1= not at all knowledgeable about Bt-brinjal + slightly knowledgeable, 2= somewhat knowledgeable, 3= moderately knowledgeable + highly knowledgeable)
Respondent's age	AGE_bt	Respondent's age in years
Total farm land area	Farmsize_bt	Total amount of land (owned farm land and rented land)
Education	Education_bt	Categorical variable (1=no schooling, 2=Primary, 3=secondary, 4=college, 5=university and 6=other)
Offfarm income	Offfarm_bt	Dummy, 1 if farmers have off-farm income and 0 otherwise

Yield is an important factor to analyze the willingness to adopt a new crop variety. Thus, the yield of non-Bt brinjal (YieldnonBt_bt), the yield of Bt-brinjal (YieldBt_bt), the yield difference between the yield of Bt-brinjal and yield of non-Bt brinjal (Yielddifference_bt) are also used as continuous variables in the model for the adopter survey. Yield difference was calculated as the marketable yield of Bt-brinjal minus marketable yield of non-Bt brinjal for each respondent. Descriptive analysis from chapter 3 shows that only 48 respondents from the total 64 adopters produced both Bt-brinjal and non-Bt brinjal in the last cropping season. The respondents who produced Bt-brinjal only in the last season, reported the data for regular brinjal production from their previous cultivation of non-Bt brinjal.

Kolady and Lesser (2006) stated that prior knowledge of Bt-technology has significant impact on the adoption of Bt-technology. This study used a knowledge variable to see the effects of knowledge about Bt-brinjal on the adoption of Bt-brinjal in Bangladesh. A categorical independent variable, knowledge about Bt-brinjal (KNOWLEDGE_bt) is also used in the model. The farming practice, demographic and other contextual characteristics of farmers may differ significantly from each other (Kolady and Lesser, 2006). The variables included in the model were selected based on the technology adoption theories. A number of socio-demographic control variables are also included in the model including, the age of the adopters (AGE_bt), education level (Education_bt), total land area including own farm land and rented land (Farmsize_bt) and whether the respondent had off-farm income (OFFFarm_bt).

4.3.2 Model Specification (Adopter Survey)

A model specification check is used to choose the best model among 3 models for the adopter survey data. The three models (A, B, C) were run using several explanatory variables (see Table 4.3).

Let us consider, model A and model B, where the yield of Bt-brinjal (YieldBt_bt) and the yield of non-Bt Brinjal (YieldnonBt_bt) are included in model A as two separate variables, while the difference between these two variables (Yielddifference_bt) is included in model B. Results are very similar in both models. However, model A (Pseudo R^2=0.43) has a better goodness of fit than model B (Pseudo R^2=0.38). In model A, the coefficient for YieldBt_bt has a negative value but is significant for reason 4 (Others), which means if the yield of Bt-brinjal increases, adopters are less likely to pick reason 4 (Others) than the reference outcome (Reason 2: Bt-brinjal requires a fewer number of pesticide applications than non-Bt brinjal) as their primary reason for being willing to adopt Bt-brinjal. These adopters are willing to adopt Bt-brinjal because it needs fewer pesticide applications than non-Bt brinjal. A new variable Yielddifference is used in model B but it is not significant. Thus, model A is the preferred model compared to model B.

Moving from model A to model C, the variable, BRNJLPRDCTN_bt was dropped in model C because it was not significant in model A and instead three other variables (Yielddifference_bt, MRKTCHNNL_bt, VARIETY_bt) were included in model C. Explanatory variables included in model C can explain 40% of the variation in the dependent variable. VARIETY_bt is not significant at all in model C but Yielddifference_bt and MRKTCHNNL_bt are significant for reason 3 (higher marketable yields) in model C. All three models use the same number of observations. This study first avoids model B because it only can explain 38% of the variations of the dependent variable while the other two models have a better goodness of fit.[8] Now, comparing model A and model C, both models have a better goodness of fit and use the same number of independent variables. Finally taking into account the expectation from this study, model C is selected to interpret the results of the adopter survey since it offers more useful insights into the factors inspiring adopter's willingness to adopt Bt-brinjal. Interpretations are provided in the next section where marginal effects are calculated.

[8] McFadden's R^2 were also calculated to compare the models and it provides comparable goodness of fit for every model.

Table 4.3: Model specification: Adopter survey results[9]

Variable	**Reason 1:** Bt-brinjal has less Fruit and Shoot Borer (FSB) insect infestations.			**Reason 3:** Marketable yield is more than non-Bt brinjal			**Reason 4:** Others		
	Model A	**Model B**	**Model C**	**Model A**	**Model B**	**Model C**	**Model A**	**Model B**	**Model C**
DISTRICT_bt	0.947 (1.08)	.867 (1.00)	0.342 (1.01)	**2.624 (1.33) ****	**2.501 (1.32) ***	1.754 (1.32)	**7.530 (4.29) ***	**5.432 (3.00) ***	5.776 (3.75)
ROBI_bt	0.697 (1.24)	0.973 (1.15)	1.238 (1.24)	**2.854 (1.47) ***	**2.999 (1.43) ****	**3.330 (1.61) ****	0.227 (2.83)	0.230 (2.24)	0.332 (2.56)
BRNJLPRDCTN_bt	-2.313 (2.70)	-2.159 (1.85)	NA	0.916 (3.05)	1.344 (2.30)	NA	-3.399 (5.65)	-4.073 (4.10)	NA
MRKTCHNNL_bt	NA	NA	-1.436 (1.15)	NA	NA	**-2.828 (1.42) ****	NA	NA	-1.538 (1.74)
VARIETY_bt	NA	NA	-0.522 (1.25)	NA	NA	1.770 (1.97)	NA	NA	3.471 (3.27)
PestnonBtFSB_bt	-0.034 (0.03)	-0.025 (0.02)	**-0.050 (0.02) ****	**-0.085 (0.04) ****	**-0.078 (0.03) ****	**-0.071 (0.03) ****	-0.176 (0.13)	-0.131 (0.10)	-0.162 (0.10)
PestnonBtOther_bt	**0.178 (0.09) ***	0.155 (0.09)	0.156 ()0.10	0.070 (0.12)	0.051 (0.12)	0.102 (0.12)	0.354 (0.29)	0.239 (0.22)	0.048 (0.19)
PestBtOther_bt	0.042 (0.11)	-0.021 (0.09)	-0.004 (0.08)	**0.282 (0.13) ****	**0.241 (0.11) ****	**0.252 (0.11) ****	**0.575 (0.28) ****	**0.385 (0.19) ****	**0.515 (0.28) ***

[9] The base outcome category is reason 2: Bt-brinjal requires fewer pesticide applications than non-Bt brinjal.

YieldnonBt_bt	-0.015 (0.01)	NA	NA	-0.001 (0.01)	NA	NA	0.008 (0.03)	NA	NA
YieldBt_bt	-0.019 (0.01)	NA	NA	-0.021 (0.01)	NA	NA	**-0.132 (0.07) ***	NA	NA
Yielddifference_bt	NA	-0.004 (0.006)	-0.002 (0.006)	NA	-0.009 (0.008)	**-0.015 (0.009) ***	NA	-0.033 (0.02)	-0.016 (0.01)
Knowledge_bt	-1.37 (1.05)	-1.156 (0.92)	-1.194 (0.89)	-1.515 (1.20)	-1.341 (1.06)	-1.429 (1.15)	**-5.170 (3.00) ***	**-4.515 (2.12) ****	**-4.853 (2.33) ****
AGE_bt	0.036 (0.04)	0.018 (0.04)	0.048 (0.042)	**0.114 (0.06) ***	**0.102 (0.05)***	**0.150 (0.06) ****	0.086 (0.08)	0.020 (0.07)	0.078 (0.07)
Farmsize_bt	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.0001 (0.003)	0.0002 (0.002)	-0.001 (0.003)	-0.009 (0.01)	-0.005 (0.008)	-0.004 (0.009)
Offfarm_bt	0.928 (1.27)	0.248 (1.13)	0.440 (1.07)	**3.846 (1.61) ****	**3.432 (1.52) ****	**3.776 (1.60) ****	**7.281 (4.37) ***	3.222 (2.46)	**5.160 (2.45) ****
Intercepts	5.178 (5.12)	3.569 (3.80)	2.635 (3.97)	-3.809 (6.18)	-5.351 (5.15)	-6.309 (5.37)	4.707 (7.71)	4.817 (6.68)	-3.092 (8.09)
Log likelihood							**-43.05**	**-47.53**	**-45.86**
Pseudo R^2							**0.43**	**0.38**	**0.40**
McFadden's R^2							**0.43**	**0.38**	**0.400**
Maximum Likelihood R^2							**0.671**	**0.619**	**0.639**
Count R^2							**0.483**	**0.467**	**0.450**
AIC							**3.169**	**3.184**	**3.262**
BIC							**53.362**	**45.936**	**58.957**

Note: * indicates significance at 10%, ** indicates significance at 5% and standard errors are in the parentheses

4.3.3 Interpretation of Results (Adopter Survey)

Table 4.4 presents the estimated results from the multinomial logit model based model C (see Table 4.3). These results provide insights into the direction of the relationship between the choice category and the explanatory variables. Farming practices are found to be correlated with the adoption of a new technology. Krishna and Qaim (2007) stated that the more the expenditures on chemical pesticide are saved due to Bt-technology, the higher the probability of willingness to adopt Bt-technology. The coefficient for PestnonBtFSB_bt, which is the total number of pesticide applications in the non-Bt brinjal fields to control FSB insects, is significant and negative, when respondents indicated less FSB insect infestation (reason 1) as their primary motivation for willingness to adopt, as well as higher marketable yields (Reason 3) and it is not significant for other adoption motivations. This means that for a one unit increase in the number of pesticide applications to control FSB insects in the non-Bt brinjal fields, adopters are less likely to pick reason 1 (less FSB insect infestation) and reason 3 (higher marketable yields) as their main reason for being willing to adopt Bt-brinjal in the next cropping season relative to the base outcome 'fewer pesticide applications'.[10] Bt-brinjal is resistant to the FSB insect and substitutes for pesticide applications. Therefore, the farmers who spray more pesticides to control FSB insects, are more likely to adopt Bt-brinjal. The total number of pesticide applications to control insects other than the FSB insects in Bt-brinjal fields, (PestBtOther_bt) has a positive and significant effect, meaning that for a single time increase in the number of pesticide applications to control other pests adopters are more likely to pick reason 3: higher marketable yields and reason 4 (Others) to support their willingness to adopt Bt-brinjal. Bt-brinjal needs more care than non-Bt brinjal because it gets infested with other insects (not FSB) very easily and weather sensitive. During data collection, many adopters claimed that a disease, called wilting has been becoming a major problem in Bt-brinjal fields.

[10] The size of the coefficients is discussed in the next section using marginal effects.

Table 4.4: Parameter estimates from Multinomial Logit Model: Adopter Survey (Reason 2: Bt-brinjal requires a fewer number of pesticide applications than non-Bt brinjal, base outcome)

Variables	**Reason 1:** Bt-brinjal has less Fruit and Shoot Borer (FSB) insect infestation.	**Reason 3:** Marketable yield is more than non-Bt brinjal	**Reason 4:** Others
DISTRICT_bt	0.342 (1.01)	1.754 (1.32)	5.776 (3.75)
ROBI_bt	1.238 (1.24)	**3.330 (1.61)****	0.332 (2.56)
MRKTCHNNL_bt	-1.436 (1.15)	**-2.828 (1.42)****	-1.538 (1.74)
VARIETY_bt	-0.522 (1.25)	1.770 (1.97)	3.471 (3.27)
PestnonBtFSB_bt	**-0.050 (0.02)****	**-0.071 (0.03)****	-0.162 (0.10)
PestnonBtOther_bt	0.156 (0.10)	0.102 (0.12)	0.048 (0.19)
PestBtOther_bt	-0.004 (0.08)	**0.252 (0.11)****	**0.515 (0.28)***
Yielddifference_bt	-0.002 (0.006)	**-0.015 (0.009)***	-0.016 (0.01)
Knowledge_bt	-1.194 (0.89)	-1.429 (1.15)	**-4.853 (2.33)****
AGE_bt	0.048 (0.042)	**0.150 (0.06)****	0.078 (0.07)
Farmsize_bt	0.001 (0.002)	-0.001 (0.003)	-0.004 (0.009)
Offfarm_bt	0.440 (1.07)	**3.776 (1.60)****	**5.160 (2.45)****
intercept	2.635 (3.97)	-6.309 (5.37)	-3.092 (8.09)
Log likelihood			**-45.855631**
Pseudo R^2			**0.4002**
McFadden's R^2			**0.400**

Note: * indicates significance at 10%, ** indicates significance at 5% and standard errors are in the parentheses

The winter variable (ROBI_bt) is significant and positive for reason 3, meaning that the farmers who like to grow vegetables in the winter season are more likely to choose reason 3 (higher marketable yields) to support their higher willingness to adopt Bt-brinjal compared to the base outcome category (Reason 2: fewer pesticide applications). In the winter season, brinjal plants face less FSB insect infestation as well as less infestation with other insects. Therefore, Bt-brinjal farmers expect higher marketable yields in the winter season than the other season. The coefficient for MRKTCHNNL_bt has a negative sign but is statistically significant at the 5% level of significance for reason 3. The farmers who like to sell their vegetables in the local market (directly to local consumers), are less likely to choose reason 3 (higher marketable yields) than the reference reason 2 (fewer pesticide applications). The influence of this variable could be different from one farmer to another farmer (i.e. small-scale farmers, large scale farmers) and also depends on the market facilities.

Along with the other variables, a number of sociodemographic factors such as Knowledge_bt, AGE_bt, Farmsize_bt and Offfarm_bt were also included in the model. Bt-brinjal has been produced in Bangladesh since 2014. Therefore, the knowledge variable could positively or negatively influence the adopters' willingness to adopt Bt-brinjal. Most of the adopters claim themselves as somewhat knowledgeable about Bt-brinjal. Knowledge_bt is significant and negative for reason 4, meaning that as the level of knowledge about Bt brinjal increases, adopters are less likely to pick reason 4 (Others) rather than reason 2 (fewer pesticide applications). Thus, the knowledgeable adopters recognize that an important advantage of Bt-brinjal is fewer pesticide applications. The age of the farmer (AGE_bt) has a positive and significant effect for reason 3 (higher marketable yields) relative to reason 2 (fewer pesticide applications), suggesting that older farmers place more emphasis on the ability to receive higher marketable yields from Bt-brinjal relative to younger farmers. Adopters who have off-farm income, are more likely to pick reason 3 (higher marketable yields) and 4 (Other) compared to reason 2 (fewer pesticide applications).

4.3.4 Marginal Effects (Adopter Survey)

4.3.4.1 The Marginal Effect of Winter Variable (ROBI_bt)

Marginal effects are calculated and presented in Table 4.5. The marginal effect of the winter season (ROBI_bt) is significant for reason 3 (higher marketable yields) (see Table 4.5). The interpretation of the marginal effect of the winter season variable is that for adopters who tend to grow vegetables in the winter season, their probability of choosing reason 3 (higher marketable yields) will increase by 39.90% compared to the base outcome category (fewer pesticide applications). A discussed previously the winter season is one of the major seasons for vegetable production in Bangladesh and there is less insect infestation in the vegetable crops during the winter season. However, Kolady and Lesser (2006) found that the kharif season (summer season) is significant for the early adoption of Bt-brinjal.

4.3.4.2 The Marginal Effect of Number of Pesticide Applications in the Bt-Brinjal Fields to Control Other Insects (PestBtOthers_bt)

Bt-brinjal is resistant to the fruit and shoot borer insect but the FSB insect is not the only insect that damages the brinjal fruits. Other insects that affect the brinjal fruits include beetles, leaf-rollers and brinjal lacewings. The fruit and shoot borer insect is one of the dangerous insects because it infests the brinjal fruit from the inside and thus it damages 80% of the edible portion of a brinjal fruits. However, Bt-brinjal only provides resistance to the FSB insects and farmers may still need to use pesticides to control other pests. This study finds that the marginal effect of PestBtOther_bt is significant for reason 1 (fewer FSB insect infestations) and reason 3 (higher marketable yields) (see Table 4.5). The marginal effects suggest that for every additional application of pesticides to control other insects, adopters are 4.39% more likely to pick reason 3 (higher marketable yields) and 3.76% less likely to pick reason 1 (less FSB insect infestations) as their main reason to adopt Bt-brinjal in the following season.

4.3.4.3 The Marginal Effect of Difference between Bt-brinjal and Non-Bt Brinjal Yields (Yielddifference_bt)

As stated earlier, improved yield is an important factor in the adoption of a GM crop. Adopter farmers are producing both Bt-brinjal and non-Bt brinjal at the same time in their fields. Yield differences between Bt-brinjal and non-Bt brinjal may influence the decision to adopt Bt-brinjal. Results showed that the marginal effect of the yield difference is negative and significant for reason 3 (higher marketable yields). The size of the effect, however, is fairly small. If the yield difference between the yield of Bt-brinjal and yield of non-Bt brinjal for a farmer increases by one unit, the adopter farmers are 0.23% less likely to pick higher marketable yields as the main reason for being willing to adopt Bt-brinjal relative to fewer pesticide applications as the main reason.

4.3.4.4 The Marginal Effect of Socio-demographic Factors

Kolady and Lesser (2006) found that there is a significant difference in the sociodemographic characteristics of the early adopters and late adopters of Bt-brinjal. Marginal effects show that age of adopters has a positive and significant influence on reason 3 (higher marketable yields) as the motivation to adopt Bt-brinjal. As the respondent’s age increases by one year they are 1.91% more likely to pick reason 3 (higher marketable yields) as their main reason for their willingness to adopt Bt-brinjal. Off-farm income also has a positive and significant effect on reason 3 (higher marketable yields) as the primary motivations for Bt-brinjal adoption. The effect is relatively large: if adopter farmers have the off-farm income they are 58.73% more likely to pick reason 3 (higher marketable yields) as their main reason for being willing to adopt Bt-brinjal in the next cropping season.

Table 4.5: Marginal effects: Adopter survey

Variables	**Reason 1:** Bt-brinjal has less Fruit and Shoot Borer (FSB) insect infestation.	**Reason 3:** Marketable yield is more than non-Bt brinjal	**Reason 4:** Others
DISTRICT_bt	-0.179 (0.178)	0.2515 (0.169)	0.0112 (0.028)
ROBI_bt	-0.189(0.239)	**0.3990 (0.233)***	-0.0026 (0.006)
MRKTCHNNL_bt	0.068 (0.206)	-0.2795 (0.179)	0.00007 (0.003)
VARIETY_bt	-0.377 (0.270)	0.3786 (0.273)	0.0076 (0.018)
PestnonBtFSB_bt	-0.0013 (0.005)	-0.0049 (0.005)	-0.00025 (0.000)
PestnonBtOther_bt	0.0213 (0.015)	-0.0046 (0.012)	-0.00016 (0.000)
PestBtOther_bt	**-0.0376 (0.017)****	**0.0439 (0.016)****	0.00103 (0.002)
Yielddifference_bt	0.0016 (0.001)	**-0.0023 (0.001)***	-0.000025 (0.000)
Knowledge_bt	-0.0643 (0.159)	-0.0744 (0.149)	-0.0084 (0.021)
AGE_bt	-0.01049 (0.008)	**0.01914 (0.007)****	0.00031 (0.000)
Farmsize_bt	0.00053 (0.0003)	-0.00042 (0.0003)	-0.000011 (0.000)
Offfarm_bt	-0.4439 (0.229)	**0.5873 (0.226)****	0.00902 (0.024)

Note: * indicates significance at 10%, ** indicates significance at 5% and standard errors are in the parentheses

4.4 Multinomial Logit Model: Non-adopter Survey

4.4.1 Description of the Dependent and Explanatory Variables: Non-adopter Survey

For the non-adopter survey data, a MNL model was also used with Y as the dependent variable where, Y= choice by non-adopters of the most important reason for willingness to adopt Bt-brinjal. The non-adopters are those farmers who produce brinjal in their fields but do not have experience of producing Bt-brinjal. Table 4.6 represents the description of the dependent variable and the response categories for the dependent variable, while Table 4.7 represents the description of the explanatory variables included in the non-adopters model. Four important response categories were used for the dependent variable, including: Reason 1: Bt-brinjal requires fewer pesticide applications than non-Bt brinjal (base outcome response category); Reason 2: Marketable yield is more than non-Bt brinjal; Reason 3: Neighbour farmers produced Bt-brinjal recently and so, the non-adopters are interested to produce Bt-brinjal in the next cropping season and Reason 4: Other reasons. This model used the same base outcome response category to compare the results of the adopters and non-adopters survey, although reason 3 differs between the two models given the different adoption context. Several explanatory variables were also included in the model.

As with the adopter survey, this model included a number of dummy variables. The winter season variable (ROBI-nBt), selling vegetables in the local market (MRKTCHNNL_nBt) and the knowledge variable (KNOWLEDGE_nBt) are used as dummy variables in the model. In addition, the variable seed sources (SEEDSOURCE_nBt) was used as a dummy variable, where 1 means farmers obtain their vegetable seeds from the local dealers and 0 otherwise. As mentioned earlier, local dealers sell different vegetable seed varieties. Farmers could collect their vegetable seeds from other sources including their neighbour farmers, own saved seeds, local extension office, BARI and other NGOs. Bt-brinjal seeds are not available in the market and thus seed sources may influence farmers' willingness to adopt Bt-brinjal. The total number of pesticide applications (APPLICATION_nBt), respondent's age (AGE_nBt) and total farm land area owned by non-adopters (TOTALLAND_nBt) are used as continuous variables in the model. Level of education (EDUCATION_nBt) is used as a categorical independent variable in the model, where 1=no schooling, 2=Primary, 3=secondary, 4=college, 5=university and 6=other. In the non-adopter model, total land area (TOTALLAND_nBt) does not include rented land because of missing information for the quantity of rented land.

Table 4.6: Description of the dependent variable (Non-adopter survey)

Dependent Variable	**Code**	**Description of Response Categories**
What is the most important reason that drives non-adopter's willingness to adopt Bt-brinjal	**1**	**Reason 1:** Bt-brinjal requires fewer pesticide applications than non-Bt brinjal (base outcome)
	2	**Reason 2:** Marketable yield is higher than non-Bt brinjal
	3	**Reason 3:** Neighbour farmers produced Bt-brinjal recently and so, interested in producing Bt-brinjal in the next cropping season
	4	**Reason 4:** Other reasons

Table 4.7: Description of the explanatory variables (Non-adopter survey)

Independent Variables	**Code**	**Description**
Winter Season	**ROBI_nBt**	Dummy, 1 if main vegetable growing season is winter season (Robi Season) and 0 otherwise
Vegetables sell in the local market	**MRKTCHNNL_nBt**	Dummy, 1 if farmers sell their vegetables directly to the local market and 0 otherwise
Seed source	**SEEDSOURCE_nBt**	Dummy, 1 if farmers collect vegetable seeds from the local dealers and 0 otherwise
Total number of pesticide applications	**APPLICATION_nBt**	Continuous Variable, total number of pesticide applications during the last cropping season
Knowledge	**KNOWLEDGE_nBt**	Dummy, 1 if not knowledgeable at all about Bt-brinjal and 0 otherwise
Age of non-adopters	**AGE_nBt**	Continuous variable (years)
Education	**EDUCATION_nBt**	Categorical variable (1=no schooling, 2=Primary, 3=secondary, 4=college, 5=university and 6=other)
Total land	**TOTALLAND_nBt**	Continuous variable, total owned land use for farming

4.4.2 Results: Non-adopter Survey

Table 4.8 presents the parameter estimates from the Multinomial Logit Model for the non-adopter survey. The socio-demographic characteristics of the non-adopters were not significant in explaining the primary reason for being willing to adopt Bt-brinjal in Bangladesh. Technology adoption studies (Alexander and Mellor, 2006; Kolady and Lesser, 2006 and Krishna and Qaim, 2007) find that social-demographic characteristics may have some influencing power in the technology adoption decision. However, while socio-demographic characteristics may be important in the decision whether (or not) to adopt a new crop variety, this study finds that they do not help explain *why* farmers are willing to adopt Bt-brinjal.

Similar results are found for the winter season variable in both the adopters and non-adopters survey. The coefficient for the "ROBI_nBt" variable is positive and significant for both reason 2 (higher marketable yields) and reason 3 (influenced by neighbour farmers). It means that if a non-adopter's main vegetable growing season is the winter season then they are more likely to pick reason 2 (higher marketable yields) and reason 3 (influenced by neighbour farmers) as their primary motivation for being willing to adopt Bt-brinjal in the next cropping season.

The coefficient for seed source (SEEDSOURCE_nBt) has a negative sign and is significant for reason 3, suggests that if non-adopters obtain vegetable seeds from a local dealer, they are less likely to choose reason 3 (influenced by neighbour farmers) compared to reason 1 (fewer pesticide applications). Krishna and Qaim (2007) found that farmers are willing to adopt a technology while they are gathering information from local private dealers. Non-adopters are those farmers who have never produced Bt-brinjal before. Therefore, they do not have proper information about Bt-brinjal. Farmers typically go to local markets to gather information about new crop varieties. Therefore, local dealers may be the initial information providers to the farmers, although other sources, including the Department of Agricultural Extension, BARI, NGOs and other private seed companies, also play role in providing information.

The coefficient for "MRKTCHNNL_nBt" is positive and significant at the 5% level of significance for reason 2 (higher marketable yields) and Reason 3 (influenced by neighbour farmers). If the non-adopters like to sell vegetables in the local market compared to other market channels (for example, directly in the town/city market and through commission agents), they are more likely to pick reason 2 (higher marketable yields) and 3 (influenced by neighbour farmers) relative to reason 1 (fewer pesticide applications) as their primary reason for being willing to adopt Bt-brinjal. This result differs from the adopter survey results where the MRKTCHNNL_bt has a negative relationship with the higher marketable yields reason (see Table 4.4).

Table 4.8: Parameter estimates from multinomial logit model: Non-adopter survey (Reason 1: Bt-brinjal requires fewer pesticide applications than non-Bt brinjal, base outcome)

Variables	**Reason 2:** Marketable yield is more than non-Bt brinjal	**Reason 3:** Neighbour farmers produced Bt-brinjal recently and so, interested to produce Bt-brinjal in the next cropping season	**Reason 4:** Others
ROBI_nBt	**3.26 (1.42)***	**6.13 (2.71)***	0.64 (1.48)
SEEDSOURCE_nBt	-0.64 (1.66)	**-4.02 (2.36)****	0.11 (1.42)
MRKTCHNNL_nBt	**3.66 (1.70) ***	**3.97 (1.99)***	-0.22 (1.72)
APPLICATION_nBt	**-0.05 (0.02)****	**-0.10 (0.06)****	-0.01 (0.03)
KNOWLEDGE_nBt	1.11 (1.29)	2.37 (2.14)	0.06 (1.17)
AGE_nBt	0.05 (0.05)	0.11 (0.08)	0.05 (0.05)
EDUCATION_nBt	-0.67 (0.79)	-1.77(1.07)	0.09 (0.87)
TOTALLAND_nBt	-0.004 (0.005)	0.002 (0.005)	0.001 (0.003)
intercept	-2.22 (3.30)	-3.29 (4.66)	-4.02 (3.48)
Log likelihood			**-33.118236**
Pseudo R^2			**0.4024**

Note: * indicates significance at 10%, ** indicates significance at 5% and standard errors are in parentheses[11]

The coefficient for pesticide applications (APPLICATION_nBt) is negative and significant at the 10 % level of significance suggesting that as the number of pesticide application increases non-adopters are less likely to choose reason 2 and reason 3 relative to reason 1. A study by Alexander and Mellor (2006) finds that producers, who used insecticides are more likely to adopt a new GM crop. Kolady and Lesser (2006) finds pesticide expenses have negative and significant effects on adopting open pollinated varieties of Bt-brinjal. They claimed that OPV growers used fewer pesticides in their field than hybrid producers. The results show that non-adopters who are heavier users of pesticides are more likely to be influenced by the opportunity to apply fewer pesticide as their primary reason for being willing to adopt Bt-brinjal in the next cropping season. The findings of the current study are therefore consistent with those of Alexander and Mellor (2006) and Kolady and Lesser (2006).

[11] To support the results from the models, the relative risk ratio was also calculated for both surveys. The relative risk ratio (rrr) is the ratio of the probability of choosing one outcome category over the probability of choosing the base outcome category is often referred to as relative risk.

Knowledge of Bt-brinjal does not seem to be significant because non-adopters do not have detailed knowledge about Bt-brinjal. However, non-adopters may have heard about Bt-brinjal through their neighbour farmers who are producing Bt-brinjal recently and this may influence their decision with respect to the adoption of Bt-brinjal at a later time. It was expected in the adopter survey that farmers (adopters) will be more knowledgeable than the non-adopters and this had a stronger effect on motivation to adopt.

4.4.3 Marginal Effects (Non-adopter Survey)

4.4.3.1 The Marginal Effect of Winter Season (ROBI_nBt)

The marginal effect of the winter season (ROBI_nBt) is positive and significant for reason 2 (higher marketable yields) (see Table 4.9). The size of the effect is fairly large, suggesting that if the main vegetable growing season for non-adopters is the winter season then they are 56.59% more likely to pick reason 2 as their primary reason to support their willingness to adopt Bt-brinjal. Similar results are found in the adopter survey.

4.4.3.2 The Marginal Effect of Marketing Channel (MRKTCHNNL_nBt)

The marginal effect of selling vegetables in the local market (MRKTCHNNL_nBt) also has a positive and is significant at the 5% level of significance and is a fairly large effect. If non-adopter farmers sell their vegetables in the local market, they are 73.65% more likely to choose reason 2 (higher marketable yields) relative to reason 1 (fewer pesticide applications). This differs from the adopter survey. The reason for the difference is unclear but it may be that the non-adopters are less knowledgeable than are adopters and more influenced by the prospect of higher marketable yields as the main reason for being willing to adopt Bt-brinjal.

Table 4.9: Marginal effects: Non-adopter survey

Variables	Reason 2: Marketable yield is more than non-Bt brinjal	Reason 3: Neighbour farmers produced Bt-brinjal recently and so, interested to produce Bt-brinjal in the next cropping season	Reason 4: Other reasons
ROBI_nBt	**0.565 (0.316) ***	0.253 (0.241)	-0.148 (0.200)
SEEDSOURCE_nBt	-0.075 (0.352)	-0.197 (0.205)	0.090 (0.215)
MRKTCHNNL_nBt	**0.736 (0.380) *****	0.144 (0.203)	-0.274 (0.207)
APPLICATION_nBt	-0.008 (0.006)	-0.004 (0.004)	0.002 (0.004)
KNOWLEDGE_nBt	0.195 (0.256)	0.103 (0.124)	-0.075 (0.181)
AGE_nBt	0.005 (0.010)	0.004 (0.003)	0.004 (0.006)
EDUCATION_nBt	-0.119 (0.167)	-0.080 (0.109)	0.068 (0.114)
TOTALLAND_nBt	-0.001 (0.000)	0.000 (0.003)	0.000 (0.000)

Note: * indicates significance at 10%, ** indicates significance at 5% and standard errors are in the parentheses

4.5 Insights from the Consumer Survey and Other Stakeholders Interviews

To apply the conceptual model of social license proposed in chapter 2, stakeholders including farmers (adopters and non-adopters), consumers, developers, NGOs and other civil society groups were interviewed. Individuals from BARI, civil society organizations, NGOs and a few consumers participated in several interviews. The purpose of the interviews was to obtain information about the stakeholders' perceptions regarding the introduction of Bt-brinjal in Bangladesh. It is important to note that personal responses may be influenced by the official position of their organizations. This section briefly summarizes key insights from the interviews.

In Chapter 3, a descriptive analysis of the consumer survey was discussed using simple statistical analysis. A total number of 30 consumers were interviewed. The majority of the consumers who were interviewed during the data collection, live near to the adopter farmers. The researcher was not able to reach other consumers who live far from the adopter farmers because of time constraints. However, a few interviews were done in the city of Dhaka where respondents' educational level tends to be higher relative to the consumers in other regions. Among all consumers interviewed, around 47% stated that they have heard about Bt-brinjal through several sources. The most important source of Bt-brinjal found in the consumer survey is their friends/relatives. However, although 47% of consumers have heard about Bt-brinjal, they are not particularly knowledgeable about this new variety of Brinjal. For example, around 70% of consumers claimed that they are not knowledgeable about Bt-brinjal at all, while only 7% claim themselves as moderately knowledgeable (see Chapter 3, Figure 3.32). While the consumers are not knowledgeable about Bt-brinjal, a brief explanatory note was provided to them before asking technology perceptions question (as explained in Chapter 3). Given the small sample size and geographically limited scope of the consumer survey, it is not considered very representative in terms of fully explaining consumer perceptions of Bt-brinjal in Bangladesh.

A few key points were covered in interviews with the representatives of relevant institutions and individuals from NGOs and civil society groups. A question was asked to the BARI representatives regarding how Bt-brinjal seed will be distributed to other farmers, who are interested to produce Bt-brinjal in the near future? BARI representatives describe that they are still producing Bt-seeds in their own research fields and in 2017 they shared Bt-seeds with the Department of Agricultural Extension. The Department of Agricultural Extension has worked with 5000 farmers all over in Bangladesh in 2017. The DAE farmers produced Bt-brinjal for the first time in 2017. They were not properly trained about the production process of Bt-brinjal and as a result, they did not find sufficient results from the Bt-brinjal production. The BARI representatives said that the DAE farmers need more training to Bt-brinjal to produce Bt-brinjal in their fields. The Bangladesh Agricultural Development Corporation (BADC) is one of the largest seed distributors in Bangladesh and BARI is going to share the Bt-seeds with the BADC in the near future. Indeed, the BARI representatives are hoping that Bt-brinjal seeds will be fully available in the market very soon.

As expected, stakeholders who have relationships with NGOs are more likely to be negative about the GM technologies. González, et al. (2009) stated that most NGOs (at both national and international levels) are the main opponents of the GM technology. In Bangladesh, UBINIG is the one of the strongest opponents of Bt-brinjal. A phone interview with an individual from UBINIG was held during the data collection period in Bangladesh. Another interview was done with an individual, who works for a civil society organization. The information recorded from these interviews is very similar. They both claim that Bt-brinjal is not good for human health or the environment. The BARI and government of Bangladesh are the main supporters for the adoption of Bt-brinjal in Bangladesh. The NGO representatives also claim that BARI is not providing all necessary information to the farmers or to consumers.

The results from this study confirm that the perceptions of stakeholders about the introduction of Bt-brinjal in Bangladesh are positive in general (with the exception of the NGOs interviewed). The stakeholders (mostly farmers) are willing to accept Bt-brinjal because it provides direct and tangible benefits to producers by controlling the FSB insect. Thus, non-adopter farmers are also interested in producing Bt-brinjal for the first time. To apply the proposed conceptual model of social license developed in chapter 2, the results suggest that Bt-brinjal currently has a high level of social license in Bangladesh. The relatively high willingness to accept Bt-brinjal among key stakeholders is influenced by tangible benefits from the crop experienced by adopters and observed by non-adopters, creates a high level of social license for the adoption of Bt-brinjal in Bangladesh.

4.6 Conclusions

This chapter presents the estimation methods and results for the adopter and non-adopter surveys. First, it was explained that a probit model does not fit the data well since it requires the use of a dichotomous dependent variable to analyze the willingness to adopt Bt-brinjal in Bangladesh. According to the descriptive analysis, the data shows a very high stated willingness to adopt Bt-brinjal among adopters and non-adopters (>90%), plus the "adopters" are part of a technology transfer project rather than having adopted the technology within a pure market setting (Bt-seeds are not available in the market). Thus, an alternative approach was needed and a multinomial logit model (MNL) was used, where the dependent variable was used as a categorical variable capturing the most important reason motivating an adopter, as well as a non-adopter, to be willing to adopt Bt-brinjal in the next cropping season.

The base outcome category in the dependent variable was: Bt-brinjal requires fewer pesticide applications than non-Bt brinjal. Both the adopter and non-adopter survey analysis used the same base category response. Results from the adopter survey show that winter season (ROBI_bt), number of pesticide application for other insects in Bt-brinjal fields (PestBtOther_bt), adopters' age (AGE_bt) and off-farm income (Offfarm_bt) are statistically significant and positively related to reason 3 (higher marketable yields) compared to reference group (reason 2: fewer pesticide applications) while, the non-adopter survey finds the equivalent results for winter season (ROBI_nBt). Age of the non-adopters is not significant at all. The yield difference between the yield of Bt-brinjal and yield of non-Bt brinjal (Yielddifference_bt) is also significant in the adopter survey results.

Selling vegetables directly to the local market shows different results for the adopters and non-adopter analysis. Adopters who sell vegetables directly to the local market are willing to adopt Bt-brinjal primarily because it needs fewer pesticide applications than non-Bt brinjal, while, non-adopters are willing to adopt Bt-brinjal primarily because it provides higher marketable yields than non-Bt brinjal and neighbour farmers grew Bt-brinjal recently and so, non-adopters are interested to grow the crop in the next season.

The last section of this chapter draws general conclusions for the role of various stakeholder groups in establishing social license for the adoption of Bt-brinjal in Bangladesh. The results from all surveys/interviews confirm that the stakeholders (most directly affected by Bt-brinjal, especially farmers and consumers) have positive perceptions towards the introduction of Bt-brinjal in Bangladesh while opponents remain within the NGO community. Therefore, the positive perceptions towards Bt-brinjal among several stakeholders indicate that the adoption of Bt-brinjal in Bangladesh has granted a strong social license.

Chapter 5 Summary and Conclusions

This fifth and final chapter summarizes the main research objectives and the major findings from the previous chapters. Returning to the research question posed at the beginning of this study, it is stated as: what are the main drivers of social license and who are the key stakeholders involved in establishing social license for the adoption of Bt-brinjal in Bangladesh? A multinomial logit model was estimated to examine the most important influence on, or reason for, willingness to adopt Bt-brinjal (for both adopters and non-adopters). The consumer survey and other stakeholders' interviews were also discussed in chapter 4 and provide brief insights into perceptions of Bt-brinjal by these other groups. Section 5.1 presents a summary of major research findings with respect to the stakeholders' attitudes towards and perceptions of Bt-brinjal and the primary reason for a positive attitude towards the adoption of Bt-brinjal. Policy and research implications derived from the major findings of this research are explored in section 5.2. Lastly, limitations of this study pertaining to the research methodology are discussed and suggestions for future research arising from this study are also made in section 5.3.

5.1 Summary of Major Research Findings

Based upon a comprehensive summary of literature on social license, technology adoption and attitudes towards agricultural biotechnology, chapter 2 presented a conceptual model of social license. To apply this conceptual model of social license in a developing country context, primary data collection was carried out in Bangladesh. Bt-brinjal was approved in Bangladesh in 2013 and currently more than 5000 Bangladeshi farmers are producing Bt-brinjal under the supervision of BARI and the Department of Agricultural Extension. However, Bt-seeds are not available in the market, Bt-brinjal fruits are sold in the market. Thus, Bt-brinjal is still in the phased–in commercialization period because full commercialization of this new crop variety will occur once Bt-brinjal seeds and fruits are available to farmers and consumers in a pure market setting.

One of the objectives of this study was to determine the major reason influencing willingness to adopt and acceptance of Bt-brinjal in Bangladesh. The descriptive analysis of the survey data was presented in chapters 3. The most obvious findings to emerge from the descriptive analysis is that stakeholders especially farmers (adopters and non-adopters) and consumers are willing to adopt Bt-brinjal in the near future. Several reasons were identified for the apparent strong willingness to adopt Bt-brinjal. A multinomial logit model finds that the primary reason for a positive willingness to adopt Bt-brinjal is that it needs fewer applications of chemical pesticides. The potential factors that influence farmers to pick this reason vary from the adopter survey results to the non-adopter survey results. The adopter analysis revealed that winter season (ROBI_bt) variable predisposes farmers to choose improved marketable yield as the main reason for adoption. Other factors influencing the adoption decision include the number of pesticide applications used to control other pests in the Bt-brinjal field (PestBtOther_bt) and age of the adopters. The yield difference between Bt-brinjal and non-Bt brinjal also affects the motivations for adoption Bt-brinjal. Results of the non-adopter survey suggest that the winter season variable (ROBI_nBt) and market channel variable (MRKTCHNNL_nBt) have significant effects on adoption aspirations. Taking together, these results suggest that providing full information on the various potential benefits from Bt-brinjal will be important in achieving social license, as different motivating factors are likely to appeal to different farmers.

The findings from the consumer survey and other stakeholder interviews suggest that most stakeholders perceived the introduction of Bt-brinjal positively. Only the interviews from the NGOs and civil society groups suggests that a very small portion of the stakeholders perceived the introduction of Bt-brinjal negatively. This research has revealed that different stakeholders may appear to have different perceptions toward a new technology, again suggesting the need for a multifaceted approach to information dissemination about this type of technology.

Like other developing country research, this study finds similar results in terms of a willingness to adopt a new GM technology. James (2015) stated that in recent years, developing countries are showing more interest to approve GM technologies because of its potential benefits to farmers within those countries. The relative strong willingness to adopt/accept Bt-brinjal among several stakeholder groups in Bangladesh suggests that there is a strong social license for the adoption of Bt-brinjal.

5.2 Implications

The finding and conclusions to this chapter may assist stakeholders including farmers (adopter/non-adopter farmers), consumers, developers and governmental regulators in understanding the drivers for the acceptability of a GM crop in a developing country context. The results of this study have a number of important policy implications for future practice.

This study finds that farmers are the one of the most important stakeholders in establishing the social license for the adoption of a crop such as Bt-brinjal. The study finds that farmers are not well trained or well informed about the technology outside of technology transfer projects. There is, therefore, a definite need for proper training programs for the farmers to introduce them to this new technology and to support the technology transfer process. The Bangladesh Agricultural Research Institute (BARI) plays a central role in providing information to the adopters. Other findings of this study are that non-adopters and consumers also do not have proper knowledge about the Bt-brinjal. Therefore, the government and developer groups will need to play a central role in providing accurate information about this technology to these groups.

Bt-brinjal is the first GM food crop in Bangladesh and it was commercialized in 2013. There is a considerable research gap in terms of evaluating the socio-economic aspects of this technology. The descriptive analysis of the survey data finds that biosafety rules and regulations are an important component in establishing social license for a new crop such as Bt-brinjal. Perceived importance of biosafety rules and regulations, and confidence in those rules and regulations, may influence the adoption process. Therefore, there is a need to understand the extent to which an adequate rules and regulations exist to facilitate the introduction of a new GM technology.

Bt-brinjal is resistant to the FSB insect and provides more marketable yields than the non-Bt brinjal. To realize the benefits of Bt-brinjal fully, Bangladesh government and other developers of Bt-brinjal need to pay attention in terms of technology dissemination and product development. Bt-brinjal is still undergoing a commercialization phase in Bangladesh. Therefore, an effective support system is required to distribute the Bt-brinjal seeds in local markets and to provide farmers with information about Bt-brinjal. BARI is the developer and plays a vital role in the technology dissemination in Bangladesh, while BADC is one of the popular seed distributors in Bangladesh. Therefore, BARI and BADC should take steps to make the Bt-brinjal seeds available in the market and to accompany this distribution with training and education for farmers.

Findings suggest that most of the stakeholders (consumers and producers of Bt-brinjal) perceived the introduction of Bt-brinjal in Bangladesh positively. However, the small sample size of the consumer survey for this study is not very representative and coution should be exercised in extrapolationg results of the consumers analysis beyond this small sample. Therefore, policy makers need to pay particular attention to how consumers view about this technology and how they learn about the technology. The opponents of the GM technologies in Bangladesh claimed that the developer groups do not provide proper information to the farmers and/or consumers. A communication gap was noticed between these stakeholders. Media may have a role to play in acting as the information provider by disseminating credible and accurate information about a new technology among stakeholder groups. Credible information dissemination by trusted public sector agencies also has an important role to play.

This study provides an example to facilitate understanding the status of social license for adopting a new GM crop in a developing country. This study suggests that technology developers in developing country play a vital role in the technology adoption process, while they need to create a good connection with producers. In developing countries, producers and consumers often do not have much access to information about new technologies and may have low levels of pre-existing knowledge about the technology. Their perceptions towards GM technology adoption likely to be significantly influenced by the technology developers, particularly if they rely on these agencies for provision of seed during the technology transfer phase of commercialization. Therefore, this study suggests that there is more attention needed to the specific economic, sociological and informational context when conducting research on technology adoption in a developing country context. Consumers from developed countries tend to be more conscious about new technologies, while developing country consumers are considerably less aware about new technologies. Information accessibility differs markedly across these two contexts. Thus, developing countries will need to invest in programs to provide information about new technologies to stakeholders to bridge the information gap. The developers and other institutions, for example the department of Agricultural Extension and BADC in Bangladesh, can contribute to facilitating information flows to consumers as well as other stakeholders. Bangladesh remains a relevant case for other developing countries for the successful adoption of a GM food crop.

5.3 Limitations of the Research and Areas of Future Research

Finally, a number of important limitations need to be considered. First, the scope of this study was limited in terms of availability of information. Social license is a broad concept and to understand the concept of social license for the adoption of a new technology, it is essential to examine stakeholders’ perceptions. This study was focused on the perceptions of Bt-technology among farmers who are current adopters and who are not yet adopters of this technology. Since Bt-brinjal is still in the phase-in commercialization period, it was not possible to assess willingness to adopt within a pure market setting. Future research could explore whether willingness to adopt and the factors influencing willingness to adopt change once the current Bt-varieties are fully commercialized. This study is also limited by the lack of information on other stakeholders' perceptions about Bt-brinjal. Due to time and resource constraints, a very limited number of consumers were surveyed and a small number of NGO representatives were interviewed to obtain a general understanding of their knowledge of and attitudes towards Bt-brinjal. The results from the consumer survey and other stakeholders' interviews cannot therefore be considered representative in determining the extent to which social license exists among stakeholders and what determines social license for these stakeholder groups. Therefore, more research is needed to examine social license for the adoption of Bt-brinjal capturing all stakeholders' perceptions. The farmer sample (both adopters and non-adopters) was also relatively small and non-random. As adoption of Bt-brinjal increases in Bangladesh in the future it would be interesting to examine adoption patterns on a larger scale once the crop is more widely established in the country.

Second, this study was done to examine the concept of social license in a developing country context. Bangladesh was selected as the country of interest but due to time constraints and the practicality of data collections, the focus was on the northeast areas of Bangladesh and might be representative only for those areas. Further research could expand the analysis to other major brinjal producing regions in Bangladesh. Furthermore, the surveys of the non-adopters and consumers were conducted in regions close to the adopter farmers. It would be interesting to examine the attitudes of consumers and farmers who have not grown Bt-brinjal yet in other regions further from the adopter farmers.

Third, the current study focuses primarily on the concept of social license in a developing country context. It would be interesting to compare the concept of social license in a developed and developing country context, and there may be scope to compare the current research findings with future research in a developed country context. The controversial nature of GM technologies influences the GM policies in different countries, for example, Zilberman et al., (2013) identified four reasons for differences in GM policies in the US and Europe. This study did not evaluate GM policies in Bangladesh. Thus further research needs to be done to examine GM policies in a developing country context and how it differs in a developed and developing country context.

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Appendix 1 The Exemption Letter from Behavioural Research Ethics Board

UNIVERSITY OF SASKATCHEWAN

To: Dr. Jill Hobbs, Professor
Agricultural and Resource Economics
College of Agriculture and Bioresources

Student: Asha Roy

Date: February 14, 2017

Re: BEH 17-47

Thank you for submitting your application entitled "Exploring the Drivers of Social License: Adoption of Bt-Brinjal in Bangladesh". The application meets the requirements for exemption status as per **Article 2.5 of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans, December 2014**, which states "*Quality assurance and quality improvement studies, program evaluation activities, and performance reviews, or testing within normal educational requirements when used exclusively for assessment, management or improvement purposes, do not constitute research for the purposes of this Policy, and do not fall within the scope of REB review.*"

It should be noted that though your project is exempt of ethics review, your project should be conducted in an ethical manner (i.e. in accordance with the information that you submitted). It should also be noted that any deviation from the original methodology and/or research question should be brought to the attention of the Behavioural Research Ethics Board for further review.

Please revise the consent form to reflect an exemption from the REB or delete the sections regarding REB approval.

Sincerely,

Vivian Ramsden, PhD
Behavioural Research Ethics Board
University of Saskatchewan

Appendix 2 The Adopters Survey Questionnaire

Survey Questionnaire: Bt-brinjal farmer (Adopter)

Understanding the Status of Social License: Adoption of Bt-brinjal in Bangladesh

Respondent Number ______________________

District ______________________

Village ______________________

Date ______________________

Section A: General farming information about Bt-brinjal

1. Are you a regular brinjal producing farmer?	**Yes**		**No**	
If Yes, please proceed to the next question otherwise thank them and end survey				
2. Have you heard about Bt-brinjal before?	Yes		No	
3. If yes, do you grow Bt-brinjal?	Yes		No	
If Yes, Please proceed to the next question **If No, Please use the non Bt-brinjal farmers' survey questionnaire**				
4. How long have you been growing Bt-brinjal?	……………………………………….(Years)			
5. From where do you normally get Bt-brinjal seeds?	Codes: 1=Local Extension Office, 2= BARI, 3= Local Dealers, 4= NGOs, 5=Friends/Relatives, 6=Other (please specify)			

Section B: Farming and marketing information

1. How often do you grow vegetables?	**Mostly Robi season (1)**	**Mostly Kharif season (2)**		**All the year round (3)**
2.What types of vegetables do you grow in your field? (please indicate all of the vegetables you normally grow in your fields)	I. Potato II. Brinjal III. Onion IV. Tomato V. Cabbage VI. Cauliflower VII. Pumpkin VIII. Other (please specify)			
3. Please specify the most three important vegetables that you normally grow in your field.				
4. Do you normally grow any other major crops in your field?	Yes		No	
5. If yes, please list three major crops that you normally grow in your field?	I. Rice II. Wheat III. Sugarcane IV. Jute V. Maize VI. Other (please specify)			
6.What type of seeds do you use for vegetable production?	Hybrid seeds (1)	Open pollinated seeds (Traditional seeds) (2)		Both (3)

7.From where do you normally get your vegetable seeds?	Codes: 1=Local Extension Office, 2= Local Dealers, 3= NGOs, 4=Friends/Relatives, 5=Other (please specify)			
8.If you grow brinjal how long have you been growing brinjal in your field?	……………………………………..(Years)			
9.What proportion of the vegetables that you produce do you use for:	Consuming		Selling	
10. Where do you prefer to sell your vegetables?	Directly at a local market	Directly at a town/city market	Through commission agents	Other (please specify)
11. What is the distance between your farm and the market where you normally sell your vegetables?	………………………… (in Km)			

Section C: Information regarding Bt-brinjal and non Bt-brinjal production

Please provide information about the production of Bt-brinjal and non Bt-brinjal					
Non Bt-brinjal			Bt-brinjal		
a. Total land area that you used for non Bt-brinjal production in the last season (including own land and rented land).	………(in decimals)		a. Total land area that you used for Bt-brinjal production in the last season (including own land and rented land).	………(in Decimals)	
b. Did you find the fruit and shoot borer (FSB) insect in your	Yes	No	b. Did you find the fruit and shoot borer (FSB) insect in your Bt-	Yes	No

non Bt-brinjal fields during the last season?			brinjal fields during the last season?		
c. If yes, have you sprayed pesticides for this FSB insect in your fields?	Yes	No	c. If yes, have you sprayed pesticides for this FSB insect in your fields?	Yes	No
d. If yes, how many times did you spray pesticides over the whole season?			d. If yes, how many times did you spray pesticides over the whole season?		
e. Did you find any other pests in your non Bt-brinjal fields during the last season?	Yes	No	e. Did you find any other pests in your Bt-brinjal fields during the last season?	Yes	No
f. If yes, how many times did you spray pesticides for those other pests over the whole season?			f. If yes, how many times did you spray pesticides for those other pests over the whole season?		
g. What was the total cost of pesticides for that whole season?	………. (TK)		g. What was the total cost of pesticides for that whole season?	……….. (TK)	
h. What is the cost of non Bt-brinjal seeds per kilogram?			h. What is the cost of Bt-brinjal seeds per kilogram?		
i. What was the marketable yield (Kg/hectare) of non Bt-brinjal in that season?			i. What was the marketable yield (Kg/hectare) of Bt-brinjal in that season?		

Section D: Knowledge about Bt-brinjal

1. From where do you get information about any new crop varieties? (Please list the most three important sources)	**Codes: 1=Local Extension Office, 2=BARI, 3= Local Dealers, 4= NGOs, 5=Friends/Relatives, 6=Other (please specify)**	

2. From whom have you heard about Bt-brinjal?	Codes: 1=Local Extension Office, 2=BARI, 3= Local Dealers, 4= NGOs, 5=Friends/Relatives, 6=Other (please specify)	
3. Please mention the one most important source of information about Bt-brinjal from the above categories in question 2.		

4. How important is this source to you regarding Bt-brinjal production?				
Not at all Important (1)	Slightly Important (2)	Moderately Important (3)	Important (4)	Very Important (5)

5. How knowledgeable are you about Bt-brinjal?				
Not knowledgeable (1)	Slightly knowledgeable (2)	Somewhat Knowledgeable (3)	Moderately Knowledgeable (4)	Very Knowledgeable (5)

6. Do you think that Biosafety rules and regulations play an important role in the adoption process of Bt-brinjal?		
Yes, I think biosafety rules are important	No, I don't think biosafety rules are important	Don't know

Section E: Perceptions and attitudes toward Bt-brinjal

Please indicate the extent to which you agree or disagree with the following statements on a scale of 1 to 5; where 1 = strongly disagree and 5 = strongly agree.					
	Strongly Disagree **(1)**	**(2)**	**(3)**	**(4)**	Strongly Agree **(5)**

1. Bt-brinjal reduces the amount of pesticide spraying that is needed on your field.					
2. The yield of Bt-brinjal is greater than the non Bt-brinjal in your field.					
3 The yield of Bt-brinjal is greater than the non Bt-brinjal in your field.					
4. Bt-brinjal is more profitable than regular brinjal varieties.					
5. Bt-brinjal is good for your health.					
6. Bt-brinjal is not harmful for the environment.					

Section F: Relationship with BARI researchers and DAE (Department of Agricultural Extension) officers

1. Do you have contact with BARI regarding the Bt-brinjal that you grow?	**Yes**		**No**		
If yes, please proceed the next question otherwise go to question no. 6					
2. How often do BARI researchers visit your field?	Never (1)	Rarely (2)	Occasionally (3)	Frequently (4)	Very Frequently (5)
3. Do you get any advice from BARI researchers about how to grow Bt-brinjal?	Yes		No		
4. If yes, how useful is their advice in case of Bt-brinjal production?					
Not at all Useful (1)	Slightly Useful (2)	Somewhat Useful (3)	Moderately Useful (4)	Very Useful (5)	
5. Do you get any financial support from BARI in case of producing Bt-brinjal?	Yes		No		

<table>
<tr><td colspan="3">6. If yes, what type of financial support do you get from BARI?</td><td colspan="4">I. Seeds for free
II. Seeds for less than market price
III. Other (please specify)</td><td></td></tr>
<tr><td colspan="3">6. Do you have contact with DAE regarding the Bt-brinjal that you grow?</td><td>Yes</td><td></td><td colspan="2">No</td><td></td></tr>
<tr><td colspan="8">If yes, please proceed to the next question otherwise ignore the following questions of this section and proceed to section G</td></tr>
<tr><td colspan="2">7. How often do DAE officers visit your field?</td><td>Never
(1)</td><td>Rarely
(2)</td><td>Occasionally
(3)</td><td>Frequently
(4)</td><td colspan="2">Very Frequently
(5)</td></tr>
<tr><td colspan="3">8. Do you get any advice from DAE officers about how to grow Bt-brinjal?</td><td>Yes</td><td></td><td colspan="2">No</td><td></td></tr>
<tr><td colspan="8">9. If yes, how useful is their advice in case of Bt-brinjal production?</td></tr>
<tr><td>Not at all Useful (1)</td><td>Slightly Useful (2)</td><td colspan="2">Somewhat Useful (3)</td><td colspan="2">Moderately Useful (4)</td><td colspan="2">Very Useful (5)</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="3">10. Do you get any financial support from DAE in case of producing Bt-brinjal?</td><td>Yes</td><td></td><td colspan="2">No</td><td></td></tr>
<tr><td colspan="3">11. If yes, what type of financial support do you get from DAE?</td><td colspan="4">I. Seeds for free
II. Seeds for less than market price
III. Other (please specify)</td><td></td></tr>
</table>

Section G: Willingness to adopt Bt-brinjal

1. Are you willing to grow Bt-brinjal in the next season?	**Yes**		**No**		**Don't know**	

2. If yes, why? **(please indicate the most important one reason)**	I. Less fruit and shoot borer (FSB) insect infestation II. It requires less pesticides use III. The marketable yield is greater than the regular brinjal IV. The cost of production is less than the regular brinjal V. The seeds will be provided to me by BARI (I am part of the project) VI. Other (please specify)	
3. If No, Why? **(Please specify the most important one reason)**	I. The seeds are not available where I normally get my seeds II. Seeds are too expensive III. I believe, it is harmful to health IV. I believe, it is harmful for the environment V. I am going to grow a crop other than Bt-brinjal VI. I don't have a market for the Bt-brinjal that I produce VII. I don't see any benefits VIII. Other (please specify)	

Section H: Socio-demographic information

Sex		**Male**		**Female**	
Age	**:**				

Education	**:**	No Schooling (1)	Primary (2)	Secondary (3)	College (4)	Other Specify (5)
Farm size	**:**	Own land (in decimal)		Rented land (in decimal)		
Off-farm Occupation	**:**	Yes		No		
If yes, please indicate the type of occupation	**:**	Government Service	Small Business Holder	Teaching	Other Specify	
Annual Income	**:**	From farming	…………..(TK)	From off-farm work	……………..(TK)	

Any other comments (Optional)

END SURVEY

THANK YOU

Appendix 3 The Non-adopters Survey Questionnaire

Survey Questionnaire: Non Bt-brinjal farmer (non-adopter)

Understanding the Status of Social License: Adoption of Bt-brinjal in Bangladesh

Respondent Number ______________________

District ______________________

Village ______________________

Date ______________________

Section A: General farming and marketing information

1. Are you a regular brinjal producing farmer?	Yes		No	
If Yes, please proceed to the next question otherwise thank them and end survey				
2. Have you heard about Bt-brinjal before?	Yes		No	
3. If Yes, do you grow Bt-brinjal?	Yes		No	
If No, Please proceed to the next question If Yes, Please use the Bt-brinjal farmers' survey questionnare				
4. How often do you grow vegetables?	Mostly Robi season (1)	Mostly Kharif season (2)	All the year round (3)	
5. What types of vegetables do you grow in your field? (please indicate all the vegetables you normally grow in your fields)	IX. Potato X. Brinjal XI. Onion XII. Tomato XIII. Cabbage XIV. Cauliflower XV. Pumpkin XVI. Other (please specify)			
6. Please specify the most important three vegetables that you normally grow in your field.				
7. Do you normally grow any other major crops in your field?	Yes		No	

8. If yes, please list three major crops that you normally grow in your field?	VII. Rice VIII. Wheat IX. Sugarcane X. Jute XI. Maize XII. Other (Please specify)	

9. What type of seeds do you use for vegetable production?	Hybrid seed (1)	Open pollinated seed (Traditional seed) (2)	Both (3)

10. From where do you get your vegetable seeds?	Codes: 1=Local Extension Office, 2= BARI, 3=Local Dealers, 4= NGOs, 5=Friends/Relatives, 6=Other (please specify)	
11. If you grow brinjal how long have you been growing brinjal in your fields?	……………………………………..(Years)	

12.What proportion of the vegetables that you produce do you use for:	Consuming		Selling	
13. Where do you prefer to sell your vegetables?	Directly at a local market	Directly at a town/city market	Through commission agents	Other (please specify)
14. What is the distance between your farm and the market where you normally sell your vegetables?	………………………… (in Km)			

Section B: Information regarding brinjal production

Brinjal production information by Non Bt-brinjal farmers		
1. Total land area that you used for brinjal production in the last season (including own land and rented land).	………(in decimals)	
2. Did you find fruit and shoot borer (FSB) insects in your fields during the last season?	Yes	No
3. If yes, have you sprayed pesticides for this FSB insect in your fields?	Yes	No

4. If yes, how many times did you need to use pesticide sprays during the whole season?		
5. Did you find any other pests in your brinjal fields during that season?	Yes	No
6. If Yes, how many times did you spray pesticides for those other pests during that season?		
7. What was the total cost of pesticides for that whole season?		
8. What is the cost of brinjal seeds per kilogram?		
9. What was the marketable yield (Kg/hectare) of brinjal in that season?		

Bt-brinjal in Bangladesh

- ✓ Bt-brinjal is a new variety of brinjal which has been developed to give resistance against fruit and shoot borer (FSB) insect. The fruit and shoot borer (FSB) insect is the most voracious insect that affects brinjal.
- ✓ Bt-technology is a technology transfer project and developed by Mahyco (an Indian Company), with the collaboration of Cornell University and Funded by USAID.
- ✓ Bangladesh Agricultural Research Institute (BARI) developed four varieties of Bt-brinjal and it was approved for limited cultivation in Bangladesh in 2013.
- ✓ Now more than 200 farmers in Bangladesh are producing Bt-brinjal.
- ✓ It reduces the use of pesticide in brinjal fields and increase the marketable yield. Some estimates suggest it can reduce pesticide spraying by up to three-quarters (75%) and increase the marketable yield by over one quarter (25%) in a season.
- ✓ Bt-brinjal contains the same nutritional value as the regular brinjal.

Section C: Willingness to adopt

1. Would you willing to adopt Bt-brinjal in your field in the next season if seeds are available to you?					
Yes		No		Don't know	

2. If Yes, why? (please indicate the most important one reason)	I. My neighbours produced Bt-brinjal recently and I am interested to produce it in the next season.	

	II. The cost of production is less than the regular brinjal III. It requires less pesticide sprayings than the regular brinjal IV. Marketable yield is more than the regular brinjal V. Other (Please specify)	
3. If No, Why? (please indicate the most important one reason)	I. I haven't heard about it II. I don't believe it will provide any benefits to me III. The seeds are not available where I normally get seeds IV. The seeds are too expensive V. I believe, it may be harmful to health VI. I believe, it may be harmful for the environment VII. I don't have a market for the Bt-brinjal VIII. I don't understand how to grow Bt-brinjal IX. Other (Please specify)	

Section D: Knowledge about Bt-brinjal

1. From where do you get information about any new crop variety? (Please list the most three important sources)	Codes: 1=Local Extension Office, 2=BARI, 3= Local Dealers, 4= NGOs, 5=Friends/Relatives, 6=Other (please specify)	

2. How knowledgeable are you about Bt-brinjal?

Not knowledgeable (1)	Slightly knowledgeable (2)	Somewhat Knowledgeable (3)	Moderately Knowledgeable (4)	Very Knowledgeable (5)

3. Do you think that biosafety rules and regulations play an important role in the adoption process of Bt-brinjal?

Yes, I think biosafety rules are important	No, I don't think biosafety rules are important	Don't know

Section E: Perceptions and attitudes toward Bt-brinjal

Please indicate the extent to which you agree or disagree with the following statements on a scale of 1 to 5; where 1 = strongly disagree and 5 = strongly agree.					
	Strongly Disagree **(1)**	**(2)**	**(3)**	**(4)**	Strongly Agree **(5)**
1. I would adopt Bt-brinjal if it reduced the number of times I had to spray pesticides					
2. I would adopt Bt-brinjal if it increased the yield of brinjal					
3. I would adopt Bt-brinjal if there is less fruit and shoot borer (FSB) insect infestation					
4. I would adopt Bt-brinjal if it reduced the cost of production					
5. I would adopt Bt-brinjal if it provided more profit than regular brinjal					
6. I would adopt Bt-brinjal if it is not harmful to health					
7. I would adopt Bt-brinjal if it is not harmful for the environment					

Section F: Socio-demographic information

Sex	:	Male		Female		
Age	:					
Education	:	No Schooling (1)	Primary (2)	Secondary (3)	College (4)	Other Specify (5)
Farm size	:	Own land (in decimal)		Rented land (in decimal)		
Off-farm Occupation	:	Yes		No		
If yes, please mention the types of occupation	:	Government Service	Small Business Holder	Teaching	Other Specify	
Annual Income	:	From farming	………….. (TK)	From Off-farm work	…………….. (TK)	

Any other comments (Optional)

END SURVEY

THANK YOU

Appendix 4 The Consumers Survey Questionnaire

Survey Questionnaire: Consumer survey

Understanding the Status of Social License: Adoption of Bt-brinjal in Bangladesh

Respondent Number ______________________

Location of Survey ______________________

Date ______________________

Section A: General Information

1. Are you the primary food shopper in your household?	Yes				No	
2. How often do you purchase brinjal for your household?	Never (1)	Rarely (2)	Occasionally (3)	Frequently (4)	Very frequently (5)	
If the answer of question no. 1 is No and question no. 2 is never then please thank them and end survey otherwise proceed to the next question.						
3. How often do you do food shopping for your household?	Once a week (1)	Twice a week (2)	Three times a week (3)	Everyday (4)		
4. What type of Brinjal do you normally purchase from the market?	I. Any brinjal which are available in the market where I normally do my food shopping II. Local variety brinjal III. Hybrid brinjal IV. Other (please specify)					
5. What is the distance between your household and the market from where you normally purchase your vegetables?	…………………………… (in Km)					

Section B: Knowledge of Bt-brinjal

1. Have you heard about Bt-brinjal before?	Yes		No	
2. If Yes, from whom have you heard about Bt-brinjal? (Please indicate all the sources from where you have heard about bt-brinjal)	Codes: 1=Local farmers, 2=Local Market, 3=Friends/Relatives, 4= NGO, 5=Media (Newspaper,/TV/Radio), 6=Other (please specify)			

3. Please indicate the one most useful source of information about Bt-brinjal from the above categories in question 2.				
4. Did you find Bt-brinjal in the market from where you normally do your food shopping?	Yes		No	
5. Have you bought Bt-brinjal for your household before?	I. Yes, I bought Bt-brinjal before. II. No, I never bought Bt-brinjal before. III. I am not sure			
6. How did you recognize Bt-brinjal in the market?	I. Bt-brinjal was labelled in the market II. The retailer told me what it was III. Other (please specify)			

7. How knowledgeable are you about Bt-brinjal?				
Not knowledgeable (1)	Slightly knowledgeable (2)	Somewhat Knowledgeable (3)	Moderately Knowledgeable (4)	Very Knowledgeable (5)

Bt-brinjal in Bangladesh

- ✓ Bt-brinjal is a new variety of brinjal which has been developed to give resistance against the fruit and shoot borer (FSB) insect. The fruit and shoot borer (FSB) insect is the most voracious insect that affects brinjal.
- ✓ Bt-technology is a technology transfer project and developed by Mahyco (an Indian Company), with the collaboration of Cornell University and Funded by USAID.
- ✓ Bangladesh Agricultural Research Institute (BARI) developed four varieties of Bt-brinjal and it was approved for limited cultivation in Bangladesh in 2013.
- ✓ Now more than 200 farmers in Bangladesh are producing Bt-brinjal.
- ✓ It reduces the use of pesticide in brinjal fields. Some estimates suggest it can reduce pesticides spraying by up to three-quarters (75%) and as a result there is less pesticide residue in Bt-brinjal fruits.
- ✓ Bt-brinjal has less insect damage than the regular brinjal.
- ✓ Bt-brinjal contains the same nutritional value as the regular brinjal.

Section C: Willingness to buy

1. Would you willing to buy Bt-brinjal if it is available in the local market?					
Yes		No		Don’t know	

2. If Yes, why? (please pick the one most important reason)	I. It has the same nutritional value as regular brinjal II. It has less pesticide residue III. It has less insect damage than regular brinjal IV. Other (please specify)	
3. If No, Why? (please pick the one most important reason)	I. I haven't heard about it II. I believe it would be more expensive than regular brinjal III. I believe it may be harmful to health IV. I believe it may be harmful for environment V. I don't know enough about it VI. Other (please specify)	

Section D: Perceptions and attitudes toward Bt-brinjal

1. Do you think that biosafety rules and regulations play an important role in the adoption process of Bt-brinjal?		
Yes, I think biosafety rules are important	No, I don't think biosafety rules are important	Don't know

Please indicate the extent to which you agree or disagree with the following statements on a scale of 1 to 5; where 1 = strongly disagree and 5 = strongly agree.					
	Strongly Disagree **(1)**	**(2)**	**(3)**	**(4)**	Strongly Agree **(5)**
2. I would buy Bt-brinjal if it contained the same level of nutritional value as regular brinjal					
3. I would buy Bt-brinjal if it contained less pesticide residue than regular brinjal					
4. I would buy Bt-brinjal if it is less expensive than the regular brinjal					
5. I would buy Bt-brinjal if it was not harmful to health					

Section E: Socio-demographic information

Sex		Male		Female	
Age	:				
Family size (household members)	:				

Education	:	No Schooling (1)	Primary (2)	Secondary (3)	College (4)	Other Specify (5)
Main Occupation	:	Farming		Not Farming		
If not farming, please mention the type of occupation	:	Government Service	Business	Teaching	Other Specify	
Annual Income	:	Farming	…………(TK)	Not-farming	……………(TK)	

Any other comments (optional)

END SURVEY

THANK YOU